

MiG-21: Beyond the Myth and the Legends

Accounts from the Ace of Aces

By Mike Echo

Performance means initiative—the most valuable moral and practical asset in any form of war.

Major Sholto Douglas, Royal Air Force

Joe called Thursday afternoon and announced that Sunday's flight was a go. "The aircraft is ready and the forecast for Sunday looks quite good. Pre-flight briefing at 09:00 hours," he said. I couldn't believe I was about to fly the most formidable jet fighter the Western World had to confront on so many grounds and for so many years.



Retired Captain Joe Gano, a successful businessman and former USAF F-102 fighter pilot of the sixties, called my office one morning and, in a matter-of-fact tone, said: "How would you like to ride a MiG twenty one?" When I finished gathering myself off the floor, I replied calmly, "Sure, let me think about it for a day or two..." We continued to chat for an hour or so, exchanging airplane stories, and before I hung up I said, heart still trembling, "Yeah, I think I would like to make a couple of flights in the 21, especially if I can get some input from aces who flew against it in actual combat. It would make a good story," figuring I can secure this self-imposed condition quite easily. Little did I know I would manage to enlist the world's *Ace of all Aces* for the mission. We made a deal. I hung-up and jumped in the air, real high.

Although he did not participate in actual combat, young Captain Gano accumulated over 1,250 hours, largely in simulated intercepts opposite F-4 Phantoms, F-104 Starfighters, F-86 Sabres, British Lightnings, F-102s, and other fighters of that time. Much of it, "informally." After a twenty-five-year hiatus, Joe decided to dabble back into some

serious flying. And he went for it, all-out. With the help of his buddy Dave Cannavo, an engineer and a brilliant mechanic, he purchased and restored a little squadron of his own. The fleet, dubbed Warbirds of Delaware includes three MiG-21's, two MiG-23's and a variety of other specimen from the Soviet era.

Wilmington Airport is about two hours away from my home, and I showed up at Aero Taxi Enterprises' terminal, the home of Warbirds of Delaware, at 09:00 hours as instructed. Joe and the rest of the crew were already waiting. "We are going to fly 0165, the UM, two-sitter MiG-21" Joe greeted me. "Its parked outside, go take a look."

The delta winged Mikoyan-Gurevich MiG-21UM model is the fighter trainer equivalent of the MiG-21MF, designated Fishbed-J by NATO. Both were manufactured in the Czech Republic by order of the Soviet Air Force. The 21MF has 14,550 pounds of thrust and a weight of 16,610 lbs (0.875 T/W ratio), including internal fuel. It is twice supersonic with a maximum speed of 1,353 mph, and wing loading of some 87.5 lbs/SF. Its service ceiling is an impressive 58,000 ft, with an amazing climb rate of 36,900 ft/min. In combat gear, it is armed with one twin-barrel 23mm cannon and two Atoll AA-2 air-to-air missiles. It may appear crude, but it's a tough aircraft, designed to operate from rough fields and unfinished strips almost anywhere. The composition of its harden exterior was for years an unsolved mystery in the West. Although it lacks the finesse of an American or French fighter, it certainly looks very intimidating.

"Lets make this flight an introduction." I suggest. "I'd like to feel the aircraft out and see where I can find some discernable weaknesses in performance." I'll present the findings to our Aces and compare results with their actual performance in combat." "That's great," said



Taxiing to runway 27

Joe, "we can then fly again and see how it plays out."

Joe briefs me on the characteristics of the 21. We discuss ejection procedures, performance, and Joe's own experience flying the aircraft. I sense that Joe is apprehensive about ejecting, if it should ever come to that, and would rather try to force-land the aircraft. Seeing that so many pilots bailed out of the MiG-21 successfully, I do not agree. Before we leave for the plane, he lends me a life vest and his USAF service-day helmet for the flight. It is a nice day--great visibility, very stable cool air with hardly any wind—a perfect day for our flight. We are to fly VFR, and our ceiling will be restricted to the Class A, 18,000 ft floor. I climb into the cockpit and have just minutes to study its interior, before Joe is set to start the engine. Most of the instruments are westernized but some are still the former Soviet design. I buckle up and lock the seatbelts and parachute. I connect the oxygen hose and plug in the communication cord. We do not wear G-suits. In an emergency, ejection of both seats gets activated by either one of the pilots. I mentally position the ejection handles, check the oxygen-flow and the intercom. I then set the altimeter to the field elevation and the directional indicator to the magnetic compass. Visibility from the back seat is quite restricted and I'm hoping that, from the front seat, Joe can see more of the outside than I can. He starts the engine, calls the tower for permission and taxis to runway 27. Permission to take off, engine to 100%, rollout, afterburner deployed. At 140 knots, we bring the nose up, and at 170 we rotate. We circle east towards the ocean, where we can maneuver the aircraft with few restrictions, and in literally less than a minute we are at 15,500 ft.



In the skies of Delaware with clearance from Giant Killer

“Your airplane!” Joe says. “OK” I suggest, “lets start with steep turns at 330 knots and then do the same at a higher speed.” I make a 90° left-turn and pull 2 to 3 G max before the MiG begins to vibrate. The Angle of Attack indicator points to just 12½ units. Just to confirm, I release pressure and the vibrations die down. “Wow, is that one of the 21’s flaws, my rustic proficiency or just my imagination?” I sway into a right turn and experience the same results. It may have limited maneuverability at low speed, I note. Later, Joe would tell me that while doing a slow barrel roll, the 21 vibrates in apparent immanent stall, throughout. We increase the speed to 550 knots. I level off, bring the nose up a few degrees, and execute an aileron roll. With the lightest of touch on the stick, the MiG drills around its longitudinal axis and shoots out like a dart. We level off again and speed up with afterburner deployed. At speeds between 0.92 to 0.95 Mach, the controls stiffen and become almost inoperative as the aircraft passes through the transonic zone. This is where a supersonic pilot should be cautious in high-speed maneuvers. An entry into a split S, for example, must be executed in especially low speed since the nosedive part of the maneuver can bring the aircraft into the transonic zone just at the critical point when you need to recover by pulling up and away from the ground. The likelihood of making the recovery while in transonic speed is very low. The outcome when the aircraft is too close to the ground is not pretty. According to the MiG’s crudely translated manual, the absolute minimum altitude (bottom of the chart) required for performing a Split S, is 6,450 ft (17,000 to 20,000 ft in training), when entry speed is limited to below 325 knots. G pulls during the maneuver are limited to 3 to 4. At high altitudes and supersonic speeds the performance is even worse.

“Have you ever done a rudder roll?” Joe asks. “Let me show you,” he says and goes right into it. Although the maneuver is quite straightforward--Pitch up and full rudder--the aircraft rolls violently, like a trapped beast. Thanks to its tremendous engine prevents us from entering a stall or unintentional spin.

Joe Gano (right) and the author after an exhausting but gratifying flight



Next, I'm interested in taking the MiG into a stall. We reduce power to 60% or so, and pull the nose up. At 160 knots, the MiG begins to vibrate, and at 140 it stalls. To recover, I ease the stick foreword, increase speed and power, and then pull up to a straight and level attitude. The MiG stalls quite gently and predictably, and loses some 3,000 ft in recovery. By now, we have used-up some 1,500 liters (approx. 350 gallons), with more than 600 liters remaining to take us home safely.

As exhilarating as the experience was, I'm almost exhausted and my entire body cheers as we pick a 270° heading towards the airport. We start losing altitude and request permission for a low pass over runway 27. Landing is quite tricky in any delta-wing aircraft, as ground loop could be fatal. To compensate for this handicap, the MiG-21 was designed with quite a massive and widely spread landing gear apparatus. Joe takes over as we approach the airport. Maintaining 330 knots, we make an over-pass at 1,500 ft with a 30° left turn back to downwind 27. We reduce speed to 240, drop the gear, and bleed the speed down to 200 as we enter base. Half flaps down, we turn into final. Joe drops the remaining flaps, and *talks* the aircraft down to 175 -180 knots, reaching the touchdown spot to rotate at 160. We taxi to the hangar, and shut the engine down. In less than 45 minutes of flight, we've used up some 1,800 liters of fuel and a lot of perspiration!

I remain in the cockpit for a minute or so longer trying to digest that awesome experience. I'm now determined to find out how the 21's powerful engine and its limited maneuverability at slow speed and range influenced its performance in real time combat...

A few weeks have passed since my initial flight in the MiG. I am sitting around the kitchen table of Giora Even (Epstein) and his charming wife, Sarah, in a pleasant Tel Aviv suburb. The house is unassuming, yet warm and welcoming. There are model aircraft everywhere, and a large painting of an Israel Air Force (IAF) IAI Nesher, tail

number 561, and two Egyptian MiG-21s engaged in a dogfight. Epstein is pouring coffee, and being a little heavy-handed with the milk.

I'd heard of the Retired Colonel but never met him. A close friend of mine introduced us, when he heard I was working on this story. And what an introduction that turned out to be. Because, not only is Epstein the world's Ace of all Aces, with more kills than anyone else in the jet fighter era, but also a decent individual that I'm honored to have met.

In the late 1950's, when he was first enlisted to service, Epstein planned to join the Air Force. He was sent to take the IAF's rigorous tests and medicals, but flunked the latter due to a mild heart condition. Motivated as he was, he volunteered to the paratroopers instead, and finished his service with over 600 jumps. At age twenty-five, three years after he'd been discharged, Epstein decided to give the Air Force another try. This time, the IAF chief medical examiner agreed to allow him to join flight school under the condition that, if he were successful, he would serve as a helicopter pilot. Epstein agreed. Two years later he earned his wings with *flying colors* and was sent to a helicopter unit. Although he excelled there too, he wasn't fully satisfied. He still dreamed of being a fighter pilot. He sought the opinion of a USAF cardiologist, and was deemed fit for air combat under USAF rules. Armed with this opinion and a letter from the IAF chief examiner, Epstein showed up at headquarters and submitted his demand for transfer to then IAF Chief Ezer Weitzman. He gave Weitzman an ultimatum: "You either send me to an air combat squadron or you send me to prison for insubordination, but I'm not leaving until you make the choice, I'll be waiting right outside your office." Several hours later, Weitzman appeared at the door, with the words: "You're to leave immediately for O.T.U. at squadron 113—SOB!" Epstein's career was paved with many more such ultimatums. Although the IAF can boast 38 Aces with 687 combined kills, Epstein turned out to be the Air Force's most revered fighter pilot and legendary as both a superb pilot and a fierce fighter. Of course, at home, he happily does the laundry, washes the dishes, and baby-sits for his two granddaughters.

We spent many hours in Tel Aviv and back in New York and of the many anecdotes he shared with me I will relate one air battle that taught me so much about the MiG-21 and about the ability of men to tap into their resources and out-perform them all.

An Account of the Ace of all Aces

When the Yom Kippur War erupted I was serving as Sector head at IAF Headquarters while flying as “emergency attend” at Squadron 101, the only squadron with mixed



Epstein in a 1967 photo together with his Mirage IIIC

Mirage IIIC and IAI Neshar fighters. I was already an experienced pilot with some serious action under my belt, including the Six Day War, the War of Attrition, and quite a number of scrambles here and there. Given the choice, I would rather be at the squadron in those critical days.

In the early days of the war, Headquarters looked like a beehive, with people arriving and manning positions at the War Room, Communications, Intelligence and Air Control. I was not in my element, and there was no way I would spend this war behind a desk. Things

got heated up and I rushed to Benny Peled, the IAF Commander in Chief, and gave him an ultimatum: “You either send me back to my squadron or I’m going there anyway.” He let me go. I hopped into my old Air Force-issue Deux Chevaux (French for “two horses”) and raced it like a Mustang to my airbase. From there I was taken to an airbase on the Sinai.

It is now three days since I arrived and found things hectic, but organized. I was looking forward to getting scrambled and got my share almost immediately. It's zero-nine hours and I slip into my g-suit, grab my helmet, and rush to the briefing room, where sorties are handed out. I am to lead a quartet this afternoon and hold on standby in the den—field phone in the cockpit. By noon, armament orders have been sent down to the dens and we are briefed by the squadron's commander and our intelligence officer on the situation at the battlefields and in the sky. Things do not sound so good. We pick up our charts and are driven to the aircraft.

I am assigned aircraft 561, a Nesher on loan from squadron 113. The airplane is black with soot it picked up when flown through the fire and smoke of a burning MiG-17, shot down by another pilot. I get filthy each time I touch it. I walk around the plane for my visual check as my footsteps echo inside the giant dome of the den. Two drop-tanks and two air-to-air missiles are attached to the wings. I think back to flying with the AIM-9H Sidewinders under my wings, not too long ago. That missile gave me a lot of grief and much 'practice' shooting my cannons in real-time combat. Each time we dumped our drop-tanks and the wings sprang, the missiles' warheads would snap off rendering them useless (Later Sidewinder models and the Israeli-made Shafrir II were a great improvement). I note the strong odor of jet fuel in the air and climb up the ladder, handing my helmet to the mechanic on standby. I slip into the cockpit and strap in, plug my g-suit hose, put on the helmet, and connect my oxygen tube. I will be sitting in the cockpit until our controller calls with sendoff order and coordinates. I take a deep breath off my oxygen mask while a mechanic helps me plug the communication cord and removes safety pins from my ejection seat. The signal comes in. A call from the controller on the field-phone describing targets and locations brings me back to myself in a hurry. I turn the Master Switch on and everything comes alive. Needles are moving to their initial positions like sprint-runners to the starting line, gyros humming and warning lights flashing all around. I feel a sense of security and warmth at the familiar sights, sounds and smells of the cockpit. The den's echoes are muffled as I close the canopy, signal the mechanic, and start the engine. The engine shrieks with increasing intensity to deafening levels, while the smell of burned fuel creeps from behind. I wave at the

mesmerized eyes of the ground crew and release the brakes, taxiing into the bright light of the sun. I am snug in the cockpit surveying my instruments, inputting data, and watching the flickering lights, as I've done hundreds of times before. I feel every bump and movement of the taxiing aircraft. I have become a part of the surrounding metal, glass and plastics. The plane has become an extension of my own body. We are one.

I notice my Number Two and the rest of my quartet merge into the taxiway as we keep radio silence. We taxi towards the end of runway 27 where we will begin our rollout. Although the temperatures are not the usual desert-scorching highs, it's quite warm inside the cockpit, and the anticipation is even higher. I may never return from this mission. My wife and kids may never see me again. But I deal with that fact the way I do with any other data, this time I push the thoughts away. I have no fear, never had. I have known no fear since childhood; of course, the absence of this built-in alert is a flaw, and I attempt to compensate for it with an intense focus on my skills and with an uncompromising knowledge of my equipment.

We line up on the runway while revving our engines and take off at a thundering roar. Forming an orderly formation, we turn slightly left to approximately 230° heading, toward the Great Bitter Lake, about half way south of the Suez Canal.

Today is Saturday, October 20th, fourteen days since the war has begun and my third day back from Headquarters. My wife and kids are still with my parents. They went there for the Holiday and stayed after the war broke out. It's a beautiful late afternoon. The sky is blue, with moderate temperatures on the ground and visibility as far as the eye can see. I just managed to escape a desk job and my spirit is high. I'm back at my squadron, and I already have four Sukhoi kills to my credit from yesterday's scramble. Psychologically, I'm all set for more action.

We arrive at the lake but see no enemy planes. Control insists that they are there. I can usually spot bogies from a great distance. So much so that the USAF wanted to examine my eyes. We sent them some medical information from my file, but never followed up

on it. Ah, here they are. I spot a pair of MiG-21 about twenty-four miles away, south west of the lake. They are cruising north at about 20,000 ft of altitude, northwest of us. I announce “bogies in sight,” lift the cover, and throw the weapons-activation switch up, while unfolding the guns’ trigger on the stick to its ready position. I dump my drop-tanks, break to the right toward them, and glance to verify that the others in my formation are following suit. As I lead towards the rear of the cruising MiGs, the horizon is suddenly filled with approaching MiG-21s--ten or twelve pairs--maneuvering into combat positions against the four of us. It’s a trap. The single pair was the bait, and the sharks were hiding down below. We simply didn’t see them, and neither did Air One.

The MiG-21 has a tremendous climb rate at constant speed, which I knew well before the 1967 Six Day War. An Iraqi pilot had defected and flew his MiG-21 to our base. The Air Force scrutinized the plane and IAF test pilot Danny Shapira demonstrated the MiG’s ability to climb rapidly while our Mirages were lagging behind.

As I go after Number Two of the ‘baiting pair’ and blow him with a missile, I hear my own Number Two, Edres, report that he’s leaving the formation to take on another pair; I continue to chase the leader, who tries hard to outmaneuver me.

Edres makes a sharp right-turn to position himself well within his missile’s optimum tracking angle and launches. Due to the sharp turn, his Shafrir missile has passed close to the fuselage, which emits the blazing rocket fumes into his engine’s air-intake and causes a compressor stall. His victim, though, is eliminated. I order Edres to leave for home. As I am maneuvering behind my own prey, I see Geva, another one of my pilots chasing a MiG into the distance. He shoots it down but goes after it so far that he can’t find his way back to the combat arena and returns home.

For three to four minutes, I’m still after the leader, who turned out to be the ambush planner. He’s trying to evade me using every maneuver in the book: loops, inverted flights, sharp turns, split Ss, rolls, and whatnot. I’m right behind him, pulling Gs that would knock a rock unconscious. Meanwhile, the fourth Mirage in our foursome reports

his own kill. He has run out of fuel and has also returned home. The chase brings the two of us to less than 3,000 feet and that *crazy* pilot attempts his craziest maneuver yet. At that low altitude he pulls a Split S, makes half a roll onto his back, and pulls back towards the ground. Slowing the aircraft with everything he's got, he is hoping to recover before he hits the ground. Quick glances outside the cockpit and at the altimeter help me decide not to follow this dangerous move, and I break to the left and down to cut him off at the exit (presuming he survives the stunt). I watch him exiting the S at zero altitude, raising a huge cloud of dust. I'm sure he crashed, but seconds later he emerges majestically from his own dust cloud, at almost vertical attitude, shooting out a huge column of fire from its fully deployed backburner. But, he's too slow at the exit and that's when I get him, with a short burst of my cannons. I feel for the man. He was a fighter. My heart misses a beat when I swing back and discover a 21 riding my tail, and



An oil painting by Roy Grinnell of Epstein's IAI Nesher 561 in the October 20th, 1973 air combat

nine more all around. We started with a one to six ratio and now it's me, on my own, against the ten of them. And they're waiting for me to get myself into one of their sights. "No way, Hussein," I grumble. "I'll fight you all. One MiG at a time." I'm excited and alert as adrenalin streams into my blood to every part of me. Eyes wide open; taking short breaths, I scan the sky for my prey. I know that with their inferior Atoll AA-2 missiles they'll have to line up within 11° of my six o'clock to get me. Fortunately, this can only be done one at a time. I'm in defensive mode, letting them get behind me but

looking for an opportunity to swiftly reverse positions. My angle-of-attack warning lights show solid red as I perform endless maneuvers in very slow flight. I shake the one at my tail with a sharp break and turn towards another, finding myself face-to-face with two new MiGs. They simultaneously launch missiles at me, and buzz a couple of feet above my head. All that's left for me to do is instinctively dunk inside the cockpit. I know the Atolls haven't the least chance of exploding at that close a range--and never head-on--but I'm still concerned about damage to my canopy by a direct hit. The excitement of battle fills the airwaves. Everyone in the War Room, at the squadron, Operations, and on the frequency is listening in. Announcements of kills, warnings, reports, directions and guidance are heard almost constantly. I look behind to find the next pair. Its leader is on my tail with his Number Two following right behind. I break sharply to the left and begin a slow barrel roll, delicately pulling my throttle back as I squeeze my thumb on the speed-brake switch and stick-and-rudder in a coordinated roll, letting him pass. I end the roll behind him and right on his tail, then bring him between my diamonds and squeeze. The MiG explodes so close that fragments of its fuselage fly by from all directions. I look behind and notice that with the exception of one last pair there are no other MiGs in sight. They enter, and I break to the right. They turn away

and pull up. I pull up after them. When I am perpendicular, I take my shot, and hit the Number Two at his cockpit. The pilot does not eject. At that point, his Number One decides to run. I turn towards him, at an ideal angle, and launch. The missile passes right underneath him without exploding. "I don't believe it!" I mutter, "They didn't give me one of those ancient 9Hs?" I'll never find out what happened to that missile, but I

The IAI Nesher is almost a virtual copy of the French Mirage IIIC. It is a delta wing intercept and ground support fighter manufactured by Israel Aircraft Industry. With 11,023 pounds of thrust and a weight of 15,763 lbs (0.699 T/W ratio) the Nesher is twice supersonic with maximum speed of 1,460 mph and excellent wing loading of approximately 48 lbs/SF. It is armed with two 30mm cannons and two IAI Shafrir II air-to-air missiles. It's maximum service ceiling is 55,800 ft.

missed a fifth kill in that battle. I have 800 liters, and 30 shells in each cannon--sufficient for a couple more local dogfights, but not near enough for a long chase at a 350-liter per minute burn-rate. So, I let him go. The radio is now silent. I call Control and report sufficient fuel and ammunition for additional targets. The crisp voice of the controller

comes back: “No targets in the air, return to base.” The sun begins to set on the western horizon, painting a backdrop of purple and gray up above. I cruise towards the airbase, land, and then taxi back to my den. I shut down the engine, turn switches off, release my harness, and open the canopy to the breeze of the open air. My G-suit is soaking-wet with perspiration. Any attempts to stand up fail. My legs refuse to respond to my brain’s command, spent from the intense physical stress of battle. I glance at the G-meter to find both needles stuck at the very end of each scale—way beyond their limits. The crew lifts me up and carries me down the ladder and into the small office. Peled is waiting on the phone. “Well,” he exclaims, “have you had enough?” and adds “Bring yourself back to headquarters, we need you here.” Since by now, I have more kills than anyone else in the Air Force, I can’t very well protest.

A couple of hours later, I find myself in the War Room at Headquarters. The large room full of colleagues and fellow officers and to my horror Peled rushes to greet me with hugs and kisses. Very embarrassing.

I rejoined my squadron a couple of days later for twenty-four hours and landed myself another scramble—adding three more MiG-21s to my name. Those were the last days of the war, and all in all, between October 18th and October 24th, I was credited with twelve kills of enemy planes. Seven of them were MiG-21s. My total kill of enemy planes now reached seventeen.

Judging from my conversations with Epstein and my own first-hand experience, it’s clear that the MiG-21 has limited maneuverability at low speed. What is unclear is how one Egyptian pilot could successfully recover from a Split S maneuver in less than half the minimum altitude set by the manufacturer--contradicting everything published about the aircraft, including its own Russian manual. This is going to be the subject of my next couple of test flights.

We are taking off in a few minutes and I am determined to thoroughly familiar myself with all the instruments and their positions in the cockpit before we're off to our experiment. I seat myself comfortably and take the time to get strapped in snugly and get the oxygen mask and voice-activated intercom to operate properly. Last night we decided that Joe would fly the maneuver and that I would be reading the numbers. I am well rested and eager to start. It is 09:25 hours. ATIS information Charlie reports 29.89 inches and declining; temperature 75°; due point 45°; wind 9 mph from the southwest; sky's partly-cloudy with 10 miles visibility in haze. I quickly calculate that the cloud base should be at about 10,000 ft by the time we are up there—not a perfect



"Position and hold big guy!"

day but still OK for the test. We will be flying with the belly drop-tank attached, which means we will not be able to use the air brakes. I set the fuel gauge to 2600 liters, the altimeter to the 70 ft field elevation, and reset the G meter to zero.

Our task is to match, beat or get as close as possible to the Egyptian pilot's low altitude Split S maneuver. Yet, we'll be starting off with a few handicaps. The biggest of them is our 18,000 ft safety entry altitude, bound to compromise performance. To level the playing field, I followed Dave Cannavo's simple rule of thumb that relies largely on the principals of converting Indicated Air Speed to True Air Speed. He factors 2% reduction



100% power, afterburner deployed

rate in density for every 1000 ft in altitude over the median altitude flown i.e. the air density at 18,000 ft would be 21% lesser than that at 3,000 ft hence maneuvering performance (at the higher altitude) would be 21% less efficient.

Joe starts the engine and we are taxiing to runway 27. "Wilmington tower experimental 1165 permission to take off runway two seven." Joe calls. "Position and hold" answers the tower, followed by "You may take off, big guy! Watch for traffic on your right."

With full power, afterburner deployed and Joe's cheers we accelerate to 140 knots. We rotate at 170 and are up in the air within seconds. Gear up and we make a sharp left turn towards the ocean. At a climb rate exceeding 22,000 fpm, we leave the area at 5,000 and arrive at 15,500 ft within a fraction of a minute. Joe contacts Giant Killer, the U.S. Navy Control Center as we enter the Warning Area over the ocean and report our intention to exercise maneuvers within the WA and up to 18,000 ft. We level off at 18,000 ft and immediately make a first attempt at a Split-S. We are using two ships sailing below, as a reference. We slow to 240 knots, roll over and pull +/- 3 g, recovering at an embarrassing 9500 ft and 400 knots. "O.K." I'm thinking, "a grand rehearsal?" Neither of us comments and we climb back upstairs. This time we level off at 17,800 ft, pull back to idle, and slow to 210 knots. We pitch up 10°, slow further to 200 knots and roll 180°. It already feels good. "Entry at 200 knots," I call. "Pull, pull." I encourage Joe. "Seventeen thousand feet... Sixteen thousand... Five gee... Vertical ten thousand feet per minute..." The MiG dives like an air-to-ground missile. "Angle [of attack] twenty eight degrees... Two fifty... Fourteen thousand... vertical thirteen... two eighty knots... four gee..." I keep at the numbers "Come-on Joe, pull, pull harder" I'm thinking. "Eleven five hundred... three hundred knots... vertical speed six thousand... Five gees... Angle of attack in the red... Eleven thousand... Ten Five... Ten three... Ten two... Level off... Zero vertical... That's it!" The night before we figured out that if we hit 7,000 feet in loss of altitude it would extrapolate to 3,000 ft at low altitude. "Seven Thousand Six Hundred feet, pretty damn close!"

But we were wrong. Using Dave's formula should shave 1,600 feet off the actual performance. If we had entered with 180 knots, it would justify shaving off another 350 ft. We could also have pushed the envelope



Talking the MiG down to 170 knots

further by pulling as much as 7g's (the maximum operating g-load for this craft) and saved another 2000 ft (provided we remained conscious). Of course, if you do the math,

that leaves us 650 feet below the ocean surface, which is to say, I'm glad we didn't try this at 3000 ft.

I play with the numbers and think of that Egyptian pilot on our way back to the airport and all the way home. I'm bothered with the fact that the numbers do not work. More for the Egyptian pilot than for myself. I am convinced that following the aircraft manual, a recovery from a Split-S maneuver couldn't occur in twice 3,000 feet. But is the manual *ultra conservative* by design? How else could the MiG-21 have measured-up against other western fighters of its era? Even if the Egyptian pilot had understood and utilized all of the margins outside of the envelope, he still needed to muster all of his own skills, and some superhuman resources to help him endure the emotional and physical stress of achieving it. Of Course, this was also a man who made a tactical mistake that would ultimately cost him his life, one that Epstein understood, and took advantage of, to bring that duel to a conclusion.

That night I figured there were no simple explanations. Were the two warriors able to unleash preternatural powers to overcome the impossible? I'll never know.

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