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The Development of Methods for Aviation to Penetrate the Air Defense in Local Wars

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Both new aircraft and aviation weapons of various types as well as air defense materiel have been tested in local wars. In this process modes and methods for aviation to penetrate contemporary air defense systems have been constantly sought and developed. Having analyzed the combat experience gained, foreign military specialists arrived at the conclusion that detailed research and development needs to be continued on the following of them: flying through the lethal zones of air defense weapons at maximum speeds and minimum altitudes; bypassing them by going around them or over them; overpowering systems; maneuvers to counter antiaircraft guns, missiles, and fighters; and structuring combat formations to decrease the vulnerability of aircraft to antiaircraft fire and the attacks of enemy interceptors.

Flying through the lethal zones of air defense weapons at maximum speeds. A high flight speed has always been considered the most important factor in decreasing the vulnerability of aircraft to the fire of air defense weapons. The experience of wars shows that this shortens the time that they are within the firing zone and complicates the aiming process for the antiaircraft system crew.

American military experts have established that increasing the speed exerts an influence on an aircraft's capability to penetrate the air defense only up to certain limits. In flying in a range of moderate subsonic speeds (500-900 kilometers per hour) at low or medium altitudes, this effect was clearly revealed. For example, during the conduct of the antipartisan war in South Vietnam, American aircraft usually operated at low and medium altitudes (300-1500 meters), that is, in the firing zone of small caliber antiaircraft cannons and machine guns. Combat experience and research have shown that by

doubling the speed (from 370 to 740 kilometers per hour) the vulnerability of the aircraft was decreased by four times.* However, the conditions for acquiring and attacking small-sized ground targets were worsened by a similar ratio, and the probability of crashing was increased. And the pilots were faced with a dilemma: assure the safety of the flight or fulfill the mission.

Combat practice showed that high speeds are not needed to carry out tasks over the battlefield; in those conditions maneuver takes on more significance. Problems of survivability began to be solved through increasing the maneuverability and the armor protection of direct support aircraft.

Taking into account the experience of local wars, there were manufactured and introduced into a number of the NATO armies in the mid-1970s ground attack aircraft which had a maximum speed of 720-950 kilometers per hour (A-10, Alpha Jet, and others), even though back in the 1950s no one intended to build subsonic combat aircraft.

One of the unfavorable factors connected with the use of high speed was infrared radiation. In a moderate subsonic profile, it came only from the operating engines. In addition, the heat "plume" was directed mainly to the rear, which made it possible to destroy the aircraft with infrared homing missiles only in pursuit -- from abaft. With near-sonic and supersonic speeds, because of the friction of dense layers of air the skin of the aircraft gets hot and the heat radiates in all directions. After reaching transonic speed, the radiation was detected by infrared homing heads of antiaircraft missiles at a distance of from 8 to 16 kilometers, the aircraft sort of "warned" of its coming and could be fired at already on a head-on course and before beginning its attack on a ground target.**

At this speed, the minimum safe altitude also increased, and terrain-following flight both horizontally and vertically became more difficult, which was considered a great deficiency in the tactics for penetrating the air defense.

The synthesis and analysis of the experience of local wars enabled the western military specialists to reach the conclusion that a wise limit would be near-sonic speed, at which the intensive increase of frontal resistance is just

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* International Defense Review, No. 6, 1977, p. 1064.
**Hawker Siddeley Review, No. 1, 1968, p. 21.

beginning, in conjunction with maneuver in direction and altitude to counter antiaircraft fire. The speed suitable for the best maneuverability is found specifically in that range where the optimal correlation is achieved between the number of targets destroyed and the number of aircraft shot down by ground fire.*

Flying through the lethal zones of air defense at minimum altitudes was widely used by ground attack aircraft during the Second World War, especially on the approach to the battlefield. However, it took on special significance after the equipping of air defense forces with antiaircraft missile systems with radar systems for guiding missiles. It is known that the range at which the radars of the antiaircraft missile systems can detect air targets decreases as the altitude of their flight is lowered and, consequently, the time available to the crew to prepare the missiles for launch is shortened. It was this specific condition which served as the main reason for American aviation to adopt the tactics of using low altitudes after the air defense of the Democratic Republic of Vietnam was equipped with such systems in July 1965.**

The experience of carrying out low altitude flights on portions of routes of various length and complexity enabled American aviation specialists to determine the probability of the survival of aircraft crews in the "danger" zone, where the opposition of air defense weapons was considered to be "strong." These specialists referred to the range of altitudes of about 60 to 90 meters, in which the probability of remaining unharmed was more than 75 percent, as the "corridor of survival." The altitudes of 30 to 60 and 90 to 200 meters were considered zones of "doubtful probability" (its numerical index -- 50 to 75 percent). And finally, altitudes of less than 30 or more than 200 meters, where the probability of survival was less than 50 percent, were characterized as "death zones."

It would seem that after determining the "survival corridor" the only thing left was to carry out the flights within its limits, and the task of avoiding the air defense fire would be solved. However, besides the danger of being shot down by antiaircraft weapons, the physical capability of pilots to carry out long flights close to the ground had to be taken into consideration.

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* SAE Paper, No. 050797, p. 13.
**Hawker Siddeley Review, No. 1, 1968, p. 17.

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In determining the methods for penetrating air defense, American pilots made wide use of the experimentally derived time of "illumination" of the aircraft (its irradiation by a radar) and the flight mode equation. The duration of the "illumination" influenced the selection of the altitude, the speed of the approach to the objective, and the type of maneuver for the attack. They were compared with the time necessary for preparing the air defense weapons to "repel" the attack. The availability of a reserve of time (or the lack of it) made it possible to decide on the possibility of using the main tactical advantage, represented by a low-altitude flight -- for the achievement of surprise and the completion of the attack before the opening of fire by the antiaircraft weapons (or the arrival of attacking fighters).

As confirmed by American military specialists, the effect of the surprise created by the penetration to the target at a low altitude of bombers alone (without cover or support) sometimes exerted more of an influence on the result of a raid than the participation of large supporting forces. In this much depended on the correct evaluation of the situation and the consideration of all factors exerting an influence on the selection of the method for carrying out the air attack. Thus, the simultaneous approach of the Israeli aviation groups at very low altitudes to 20 Egyptian airfields assured the achievement of complete surprise for the attack, as a result of which 374 aircraft were put out of action, and this predetermined the outcome of the 1967 "six-day" war in the Near East.* However, this type of tactical method did not have the desired effect in the war of the American aggressors against the Democratic Republic of Vietnam. They were unsuccessful in surprising the DRV's air defenses because the Vietnamese People's Army had a lot of combat experience. In spite of such advantages as decreasing the vulnerability to antiaircraft missiles, a concealed approach to the target, and a reduction in the size of the supporting forces, the American command still abandoned low altitudes flights as the method of penetrating the air defense. This decision was based on the low effectiveness of bombing attacks and the sharp increase in the loss of aircraft from the fire of antiaircraft artillery (in the first year-and-a-half in Vietnam, more than 60 percent of the overall losses of American aviation was caused by antiaircraft artillery fire).

The US air forces were forced to change their tactics. They began to operate at medium altitudes, make wide use of antimissile maneuvers and electronic countermeasures equipment, and to form combat formations taking into

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* Wehrkunde, No. 9, 1967, p. 452.

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consideration the capabilities of antiaircraft missile systems. Flights at extremely low altitudes remained the main method for penetrating air defenses only for the F-111 fighter-bomber equipped with an automatic terrain-following system and more advanced aiming and navigational systems.

Bypassing the lethal zones of air defense weapons by going over or around them, according to the experience of local wars, can be considered a very conventional tactical method (with the exception of a flight over and under the "lobes" of the detection radar systems). In the opinion of foreign military specialists, to bypass the air defense zone and freely continue the flight to the target unhindered is possible only in map exercises for staffs. Realistically, only the selection of a route which assures the minimum of activity by air defense weapons should be counted on. This method was practiced often. The possibility of its use depended on the crew having available data, received from electronic reconnaissance on a real-time basis, on the actual location of antiaircraft missile systems at the time of the delivery of the strike; on the characteristics of the radar system used for detecting air targets; on the range of the system in altitude and distance; on the configuration of the enemy's radar field horizontally and vertically, and also on the information from an aircraft's warning equipment about entry into the zone of radar illumination and the type of radars. The lack of these data and equipment would lead to failure in the attempt to bypass the air defense zones.

The specific character of local wars was often expressed in the fact that the defenders, as determined by foreign specialists, had front lines "on all sides." In the air raids in Vietnam, American aviation openly approached the Hanoi-Haiphong air defense zone from the south, west, north and east. Israeli aviation attacked objectives in Syria through Lebanon and Jordan (not counting "directly" from the south). "Bypassing" had a place under these conditions; however, it always ended with intrusion into the firing zone of air defense weapons. In order to penetrate to the target, on the final stage of the route it was necessary to employ all known methods of "evasion tactics" and military cunning. Thus, there was practically no unhindered bypassing of air defense zones by aviation strike groupings. In such a situation, quite widely used were diversionary operations and distracting maneuvers. For example, there was created the appearance of an attack from one direction by the concentration of forces in the zone of observation of the air defense radars, whereas the actual approach to the target took place from another direction while employing the necessary concealment and deception measures. In air raids in Vietnam, and in the Near East in October 1973, the combat crews of the air defense weapons were

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deceived relative to the direction of attack through the launching of decoy targets which created blips on the screens of the radar systems similar to those of aircraft.

Bypassing the lethal zone of air defense weapons by flying above them (vertically) was carried out only by the SR-71 and U-2 strategic reconnaissance aircraft, whose service ceiling exceeded 20,000 meters. However, their flights were not connected with the delivery of air strikes.

American specialists consider an overpowering penetration as the most active method of overcoming the air defense by aviation. The journal Ordans [sic] [Ordnance (?)] wrote: "In order to penetrate to important defended targets with the weapons to destroy them, American aviation had to adopt a tactic characteristic for the Second World War period -- the attempt to break through the air defense head-on. Such a tactic was adopted only when the commander had no other choice. As a consequence of the dense concentration of the defense, there was no opportunity to bypass the area or to use deceptive maneuvers."

The main method for an overpowering penetration is considered to be the assignment of a special group for suppressing the air defense. Included in its mission is the forming of a "corridor" with the use of weapons fire for the flight of the strike aircraft to the target. Usually cooperating with this group are fighters which use the method of clearing the air space in the strike area. The attacks of the strike and support groups are strictly coordinated according to time so as to deprive the enemy of the opportunity for restoring the combat capability of his air defense system or for committing his reserve forces into combat.

According to the experience of local wars, the aircraft designated for suppressing the antiaircraft missile systems and antiaircraft artillery with weapons fire usually operated in a stripped-down mode and did not have large external stores which would hinder the execution of evasive maneuvers. All of the munition stores were expended in a single attack, and therefore there was an increased requirement for accuracy of firing strikes. In the formed corridor the aircraft, loaded with bombs, usually flew in a column of aviation flights, since a wide-front formation was ruled out. Time intervals between the flights were reduced to the minimum.

The piercing of the air defense and the group strike on the assigned target

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were subordinated to a single concept, the accomplishment of which demanded comprehensive combat support. Besides the group for suppressing antiaircraft weapons, to support the bombers also in operation were electronic reconnaissance aircraft for establishing the coordinates of emitting radars and aircraft for providing active and passive jamming. Employed on a wide scale, electronic warfare activities began with jamming from zones which "bordered on" an area of combat operations which was relatively small in size. In every zone of the penetration sector there were two aircraft specially equipped with electronic countermeasures devices. However, this turned out to be insufficient for reliable enemy deception and the concealment of the strike groups' combat formations, and for preventing the guidance of antiaircraft missiles. It was established that one of the ways to solve the problem was to conduct jamming directly from the combat formations by using the onboard transmitters of the strike aircraft. By the end of the war each tactical fighter had two externally mounted pods with electronic countermeasures equipment.

The concept of individual defense required the development of special tactics different in content from the methods of jamming from zones. The limited power of the externally mounted transmitters forced the compacting of the combat formations since it was only by accurately maintaining their places in the formation at reduced distances and intervals that the electronic concealment of the makeup of the group could be assured. However, the tight combat formation had to be broken up on approach to the strike objective (at the line of formation breakup for the approach to the target) since constraint in maneuvering had an adverse influence on the accuracy of the attack. "Therefore, despite the equipping of each combat aircraft with electronic countermeasures devices to assure its direct protection, the method of jamming from zones continued to be used up to the end of the war."* Additionally, aircraft armed with antiradar guided missiles became an integral element of the aviation combat formations. For example, during the raid of US B-52 strategic bombers on Haiphong on 16 April 1972, the organization of electronic warfare for penetrating the air defense was as follows.

The strike group, consisting of 17 B-52 aircraft, carried out its flight at an altitude of 9000 meters in a column of detachments (threes) under the cover of Phantom fighter escorts. Included in the combat formation were F-105C (Wild Weasel) aircraft armed with Shrike antiradar guided missiles. During the flight to the target the aircraft received information from the crews of electronic

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* Aviation Week, No. 19, 1973, p. 7.

reconnaissance aircraft, and from the EB-66 jamming aircraft deployed in six combat patrol zones (two in each). Approximately a half hour before the arrival of the main group, along its flight route a heavy chaff curtain (passive jamming) was established, which stayed in the air for more than three hours. From on board the B-52 strategic bombers, active jamming was conducted (the aircraft which took part in the raids on the Democratic Republic of Vietnam were equipped with jamming transmitters). Thus, in the course of the massive raids, the air defense radars were suppressed with triple overlapping jamming. Despite this, the DRV air defenses found effective measures for electronic protection and shot down two aircraft: one F-105C (Wild Weasel) and one A-7E.*

"The air war over North Vietnam eliminated all doubt regarding the effectiveness of electronic countermeasures. They have gained the complete approval of the air forces. Electronic countermeasures equipment is now just as obligatory for aircraft combat sorties as are fuel and weapons," stated Aviation Week.

The basis of the tactics used by the Israeli Air Force in past armed conflicts in the Near East to penetrate the air defense consisted of the combined use of four electronic warfare methods: conducting active jamming from the on-station zones by special aircraft; individual defense (conducting jamming from the combat formation of the strike aircraft); the use of radar decoys; and the dispersal of chaff. In Lebanon (June 1982), Western specialists noted the following sequence of activities of the Israeli aviation in operations to penetrate the air defense (a well-known method of past wars was used: "blinding equals suppression"). The first stage was the launching of decoys (remotely piloted vehicles of the Mastiff and Scout types) with their periodic intrusion into the lethal zone of the antiaircraft systems. By doing this over the course of several hours the combat crews of the ground air defense weapons were kept under constant strain, their morale was lowered, and their physical strength exhausted. Aircraft making the final reconnaissance at that time determined the precise coordinates of operating radar stations. Second, the "blinding" was carried out through the employment of passive and active jamming to assure the concealed penetration of the strike groups to the targets. The third stage -- "suppression" -- called for actions by the crews to employ guided weapons of destruction against the most important air defense objectives. In the fourth stage there was a buildup of efforts (a second wave) by groups of aircraft with unguided weapons of destruction, delivering strikes with the method of

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* Aviation Week, No. 17, 1972, p. 14.

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"straddling" an area.

The antimissile maneuver became necessary after the American aviation changed over to operations from medium altitudes. By rising above the limits of effective small-caliber antiaircraft artillery fire, the aircraft entered into the zone of observation of the air defense system's ground radars. In these conditions, the tactic of "evasive action" mainly consisted of frustrating efforts to lock on to the aircraft or of the aircraft flying away from an antiaircraft missile. Having received information on the launch of a missile, the pilot immediately turned the aircraft toward the closest boundary of the antiaircraft missile system's lethal zone and tried to cross it as quickly as possible.*

Information on the launch of a missile from the ground was sent by radio from observers -- from special reconnaissance aircraft, which participated in every US air raid on targets in the Democratic Republic of Vietnam. A special onboard electronic reconnaissance device was made for the US Air Force to notify crews about their presence in a zone irradiated by the radar of an antiaircraft missile system.

Using the warning device, American pilots began to use the antimissile maneuver after a feint initiation of an attack. For this, one of the aircraft of the group intentionally remained in the "danger zone" at an altitude of 1500-3000 meters, the pilot fixed the moment of the launch of the missile and put the aircraft into a steep spiral toward the boundary of the lethal zone, while at the same time another pilot increased speed and attempted to penetrate to the strike target at an altitude of 500-800 meters. Feint attacks were sometimes carried out simultaneously from several directions.

A more complex method was used in the case when the antiaircraft missile was spotted already in the immediate vicinity of the aircraft. While maneuvering the pilot took into account the fact that the missile could change direction of flight only within definite limits. In this case, the effectiveness of the antimissile maneuver depended on the accuracy of the determination of the moment for its initiation. A big lead (a distance of up to 15 kilometers), did not result in frustrating guidance -- the missile "had sufficient control surfaces" for the necessary corrections to trajectory. Escaping from a launched missile was a new tactical method which had not been developed earlier, and it required

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* Air Force, No. 4, 1966, p. 43.

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high professional skill and special psychological training of flight personnel.

In contrast to an antimissile maneuver, a maneuver against fighter aircraft was not new. It has been known from the times of the first air battles and was employed for the withdrawal of aircraft from the area of possible fighter attack or to evade aimed fire. Bombers and two-place ground-attack aircraft combined maneuver with defensive fire from the rear cabin of the aircraft. For fighters, the only means of defense was to change flight direction because they did not have weapons which fired to the rear.

Equipping fighters with radar sights and guided air-to-air missiles led to substantial changes in the tactics for maneuvering against fighters. In the wars in Vietnam and the Near East (1965-1973), the main type of maneuver against the Phantoms and Mirages, employing the Sidewinder and Matra air-to-air guided missiles with infrared homing heads and the first modification of the radar-guided Sparrow missile, in the opinion of western specialists, was the tried and tested turn toward the attacker with the maximum possible angular velocity. By doing this the highly touted guided air-to-air missiles would miss. However, already at that time it became clear that it was necessary to detect the enemy at a distance close to the limit of human sight in order to frustrate the attack.

Receivers began to be installed on aircraft to warn about the illumination of the aircraft by the onboard radar of the fighters, but they did not help if the attack was carried out with infrared missiles when it was not required that a radar be switched on (aiming was accomplished with an optical sight). As was noted in the Western press, in the air battles over Lebanon in 1982, the Israelis used the improved Sparrow guided missile which made it possible to attack a target from a distance significantly farther than the range of visual sight. In this process, the fighters, on command of the airborne command post, could get into position for the effective employment of weapons without being detected, and if the attacked pilot was not warned about this is a timely manner by the command post or one of the other pilots in his combat formation, then he would be forced to use an antimissile maneuver rather than a maneuver against a fighter.

Being considered at the present time is the problem of making multipurpose on-board devices for warning of the launch of radar-guided and heat-seeking air-to-air missiles.

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In the American built F-15 and F-16 Israeli fighters to first participate in the air battles over Lebanon in 1982 there were installed special detection receivers, on-board jammers, and containers with heat and radar decoys. The receiver which was part of the warning system gave the pilot a signal not only about the aircraft being in the zone of on-board radar of an enemy fighter, but also about the launch of a guided missile. Simultaneously, a "command" was generated for switching on active countermeasures equipment (jamming transmitters) or for the release of "decoys" -- false targets. The infrared or radar guidance system would "lock on" to the decoy and the missile would miss the target. The use of radioelectronic countermeasure devices had to be combined with the use of a very sharp defensive turn.

Thus, the maneuvering against fighters was supplemented in local wars with new elements which assured its effectiveness even with the sharply growing offensive capabilities of fighters based on the emergence of new guided missiles.

Maneuvering against antiaircraft weapons in local wars has changed very little in comparison with the period of the Second World War. New methods of fighting against antiaircraft artillery were not found. Active and passive jamming against it was not effective since the majority of antiaircraft battery crews rarely used fire control radar, and more often used optical sights.

All of the known types of maneuvering against antiaircraft weapons -- "snaking," "scissoring," and "slipping" -- made aiming difficult for the gunner. The simultaneous initiation of the attack from various directions ("star raid") scattered the antiaircraft fire and lessened its intensity. In mastering these methods, it was required to take into consideration the already forgotten experience of the Second World War.

Foreign military specialists noted that "American aircraft were designed in accordance with the requirements of defense against ground-to-air and air-to-air missiles, but turned out to be vulnerable to fire from conventional antiaircraft artillery. Such a result should have been expected since no one assumed that aircraft would be subjected to fire from guns."*

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* Space Aeronautics, 1967, VI.

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In all of the local wars in which there was extensive employment of guided missiles, third-generation combat jet aircraft, electronic warfare equipment, and remote command and control systems, most of the aviation losses were suffered from the fire of conventional antiaircraft artillery. The task of finding effective methods for aviation to fight against it remains urgent even now.

Structuring a combat formation which will assure the reduction of aircraft vulnerability. In penetrating the air defense in local wars, all types of combat formations -- tight, loose, and dispersed -- were used.

Tight combat formations, it would seem, were already part of the past since they inhibited the maneuver of high-speed aircraft. However, as noted above, they were used during the period when the American fighter-bombers were equipped with individual electronic countermeasures devices because this made it difficult to pick out of a single target against a background of interference. However, during the launch of an antiaircraft missile aimed at the middle of an area of interference, it could damage several adjacent aircraft. Therefore, during the organization of mass raids, it would be necessary to choose between a tight combat formation, which would assure the concealment of the group's composition and also a rather dense strike, and a loose formation, which would guarantee the execution of antimissile maneuvering and security from destruction of the group by one missile.

The loose combat formation is characterized by the positioning of aircraft at increased distances and intervals, but not outside of the range of visual or radar contact. It was usually used when delivering sequential group strikes. The lethal zone of air defense weapons was penetrated by tactical groups consisting of two or three squadrons, including fighter cover.

Dispersement in depth was used most often by Israeli fighter-bombers during the 1973 war. Their combat formation over the enemy territory consisted of a column of pairs, flying at visual-contact distance. Before reaching the target, the combat formation was closed up by the wingman's increase of speed.

Dispersement along a front (for example, a "finger tip" flight formation in US tactical aviation) was used during simultaneous strikes on several targets located close to each other. US Navy carrier-based attack aircraft operated in this way in providing direct support to the Marines. In fulfilling this task, the most complicated problem consisted of dealing with the counteractions of the

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field air defenses, whose fire often could not be suppressed ahead of time. Special methods of combat support were developed for carrying out air combat actions in this situation.

The dispersed combat formation included groups of various tactical types, each of which carried out flight in its most advantageous flight mode. As a rule, there was no visual contact between groups, with each of them operating in accordance with the basic attack plan. A lot of importance was attached to the development and realization of this plan. Not having visual contact with neighboring groups, each group leader had to carefully picture their maneuvers at all stages of the combat flight.

In practice, the combining of different types of combat formations in the operational deployment of aviation forces always depended on the tactical purpose of the aircraft groups and the weapons employed.

During the treacherous attack on Lebanon in 1982, in the strikes against air defense weapons the Israeli aviation used the following combat formation (arrangement of forces): an airborne command post, electronic reconnaissance and jamming aircraft, different types of tactical groups (diversionary, cover, strike, force buildup (reserves), damage assessment). The airborne command post as well as the electronic reconnaissance and jamming aircraft were deployed in zones over the sea beyond the range of air defense weapons. Before the diversionary group was committed to combat, the location of the radar control system was precisely determined. The F-15 and F-16 fighters remained in loitering zones over the sea until the approach of the strike group.

With the approach of the fighter-bombers (Phantoms and Kfirs) to a designated line, the cover groups flew closer to the area of the strike and formed a screen; their movement was regulated by the airborne command post (E-2C Hawkeye). When Syrian fighters intent on closing with the strike group were detected, the F-16 aircraft flew to intercept them at low altitude, and the F-15 fighters remained in readiness for an attack with the Sparrow all-aspect missile. Before the beginning of the flight over the area of combat actions, a wide band of passive jamming was established. With some lead time relative to the approach of the fighter-bombers to the targets, active jamming transmitters were turned on which jammed the radar screens. Under the cover of the jamming, the strike group undetectedly penetrated the lethal zone of air defense weapons and suddenly attacked the targets. The first strikes were made on the most important objectives (mainly the radar of the antiaircraft missile system) with

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the use of guided missiles and bombs, and thereafter on other air defense objectives with the use of conventional high explosive and fragmentation bombs.*

The movement of the strike groups was also coordinated by the airborne command post. Thus, it became one of the main elements of the dispersed combat formation, taking on the complex function of controlling tactical aviation during the penetration of a combined air defense.**

Foreign military specialists believe that the appearance of airborne command posts in contemporary air defense systems cast doubt on the advisability of the use of low altitudes by the attacking side. The onboard surveillance radar of the airborne command post detects low-flying targets at a distance of 250-400 kilometers (depending on flight altitude). Therefore, the aircraft attempting to penetrate to the strike objective is "illuminated" long before it reaches the target. The surprise and effectiveness of the employed concealment and deception measures are lost.

Low-altitude flight, which was a reliable method of overcoming the counteractions of second generation air defense fighters (Starfighters, Phantoms, and Mirages), also began to lose its significance because the onboard radars of contemporary fighters (F-14 and F-15) provide for the detection of targets against the background of ground clutter and an attack from any direction.

Thus, the experience of recent combat operations has shown that the tactics for penetrating an air defense have become quite different from the mass penetration of American B-52 bombers into the Hanoi and Haiphong zones in April 1972. A trend toward the concealed penetration of single aircraft (or small groups) to important deep strike objectives without fighter escort and support forces has been clearly noted. In supporting troops and isolating the area of combat operations, there has been adopted the concept of "blinding -- suppressing," in accordance with which there is close contact between the squadron groups of tactical strike aircraft and the support aircraft -- the final reconnaissance and jamming aircraft, the fighters clearing the air space (screening force), and the escort fighters. However, this was not "penetration" of the air defense in the ordinary sense of the word, but rather an intense and

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* Flight International, 16.X, No. 3832, 1982, p. 1008.
**Defense Electronics, No. 12, 1982, p. 30.

organized battle against the air defense with all of the possible means and methods for suppressing it.

The "tactic of evasion," tested by the Americans in local wars, continues to be improved. Not one of its earlier developed methods has lost its significance. At present, acquiring a theoretical basis is a "supersonic dash" at high (or medium) altitude of the aircraft with the effective radar cross section reduced to the minimum. Penetration to the strike objective at an extremely low altitude while following the terrain has been placed at the basis of the methods for using air-launched cruise missiles. The bypassing of air defense lethal zones is mastered by the crews of all contemporary combat aircraft, which are equipped with a sensitive warning device. Maneuvers against missiles and fighters are combined with active and passive jamming. The combat formations of strike aviation retain a tendency toward dispersal, which is connected with the introduction into service of highly accurate air-to-ground weapons and airborne command posts.

However, certain tactical principles for penetrating an air defense remain unchanged. They include: the direct dependence of success on the availability of accurate real-time intelligence about the composition and location of opposing air defense groupings; the loss of surprise for the strike through the advance activities of support groups; the reduction of strike density when selecting a low-altitude flight variant; the mandatory combination of various methods of evasion based on the capabilities of the air defense systems in order to reduce their effectiveness, and also based on the air situation.

The careful analysis of the experience of actual aviation combat operations in local wars and its creative use in operational and combat training is one of the indispensable conditions for further increasing the combat readiness of the Soviet Air Forces.