SU-27 FLANKER

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A Few Words About This Program

Congratulations on your lucky purchase! Flanker opens a radically new era in flight simulation for PC; its technical characteristics and capabilities come closer to simulators used to train military and civil aviation pilots, while retaining all the advantages of the PC format and cost.

Our program simulates one of the best fighters in the world - the Su-27, which was created by the Sukhoi aircraft design bureau and which NATO calls the Flanker. This is the aircraft which in 1989 accomplished the unique "dynamic deceleration" manoeuvre named Pugachev’s Cobra for the first time. It is the pièce de résistance at many international air shows and the number of world records set by this aircraft is a record in itself.

By contrast with other simulators you won't be forced to fly a foundry pig of an aircraft in outer space and fire at your enemy with violent abandon, atomising any target with your eyes closed. Our flight model includes all the parameters of the real thing: thrust, drag, lift, induced drag, angle of attack, altitude, pressure, temperature, weight (function of fuel burn and weapons delivered), inertia, and many others. All weapons whether airborne or ground-based demonstrate the complete characteristics of the real thing: acceleration/deceleration, fuel burn, launch parameters, radius of turn, proximity detonation, size of blast, kill probability, etc.

You will not be expected to fight with harmless daydreamers, but with an extremely qualified adversary equipped with excellent modern weapons. In a word, be ready to sweat.

The program constantly handles huge volumes of calculations (equations of motion, image generation, tactics, etc.), and so requires the appropriate computer power: IBM PC-486, 66 MHz and higher are recommended. We also suggest that your PC be equipped with a VESA Local Bus or PCI system for better performance. However, for those of you with slightly lesser performance, don't worry, there's a version for you on the installation disk.

This program documentation is neither a flight manual for the fighter-pilot nor a thesis on combat tactics - there is quite a lot of appropriate literature on the subject. In this book we only want to acquaint you with the principle features of the Su-27, how to execute typical flying manoeuvres and how to employ the weapons systems, air-to-air and air-to-ground.

Where to Begin

The contents of this book are divided into two parts, each part consisting of a number of chapters. The first part contains the description of how to fly the Su27 and fight. This part contains some information unique to the Su27 fighter, so get acquainted., so if you want to ride the Flanker as a professional, you will certainly be forced to get acquainted with the most part of the information contained here in details.

The second part of the manual deals with the front-end of the program, namely the Mission Editor.

Part 1. Sukhoi Su27 "Flanker"

Chapter 1, "Introduction". The chapter you are reading includes Su27 brief design history and technical specification. It also contains the information necessary for you to place yourself instantly in the cockpit and quickly take off, without going through the entire book.

Chapter 2, "Inside the Cockpit". Here you will find the detailed information on the cockpit and avionics suite. We list all the instruments and controls of the Su27 and explain their principles of operation.

Chapter 3, "Piloting the Flanker". This chapter is intended primarily for users not proficient in the piloting of aircraft (real or computer-simulated). Here you will find out how to take off and land, fly basic aerobatics and use the navigational aids.

Chapter 4, "Weapons". Read this chapter if you want to know details about the weapons available to the Flanker and other aircraft.

Chapter 5, "Air Combat". Look up here if you don't know how to acquire and kill airborne targets. You will learn how to operate the radar, electro-optical and helmet-mounted systems.

Chapter 6, "Hitting Ground Targets". You will learn how to deliver weapons to ground and marine targets.

Chapter 7, "Warnings and Failures". To get out of an engagement alive you'll have to know how the warning systems work, how to survive aircraft failures, and how to react to airborne and ground threats.

Chapter 8, "Understanding SAMs and Countermeasures". Since our program incorporates various kinds of anti-aircraft artillery and SAM installations, you should probably want to learn how to avoid being shot down by them. Here you will also find information on missile defence.

Part 2. Mission Editor

Chapter 9, "Theatre of Play". Read this chapter if you want to know why we chose Crimea as the battlefield.

Chapter 10, "Getting Started". Here you will get acquainted with the Mission Editor basics.

Chapter 11, "Planning your mission". This chapter classifies and helps you plan pre-set missions.

Chapter 12, "Building new missions". When you might want to create a brand new mission in order to fly on your own or give it to your friends, this is the chapter you should turn to.

Chapter 13, "Miscellaneous". Here you will find information on head-to-head missions. Furthermore, we'll teach you how to sequence, edit and post-produce your air sequences into exciting "video" montages. Set-up the program to properly work with your supplementary equipment such as sound card, joystick and network hardware. Here you'll learn what preferences are available to you while working in the Mission Editor.

Part 1.
Sukhoi Su-27 Flanker

Chapter 1. Introduction

A Brief History of the Su27 Flanker

For many years Western fighter pilots considered practically all Soviet fighters as MiGs. However, times have changed and they have come to know yet another formidable name - the Sukhoi Su27, unofficially called by Russian service personnel "Zhuravlik" which stands for Crane, and designated by NATO as the Flanker. A participant at practically all international air shows and fairs, this aircraft has been selected as the cornerstone of the Russian air force into the 21st century, eclipsing all rivals.

The single-seat fighter-interceptor Su27 was created by the Sukhoi OKB (Russian designation for Design Bureau) for the fighter units of the Air Defence (Russian designation PVO) and Air Force of the Soviet Union (Russian designation VVS). The aircraft was conceived in 1969, after the Sukhoi OKB won a governmental contract to design a long-range interceptor to replace the Tu128 'Fiddler', Su15 'Flagon' and Yak28P 'Firebar' in PVO service. Furthermore, the new aircraft had to have operational characteristics surpassing those of its American analogue - the F15 'Eagle'. The prototype of the Su27 under the designation “T101” was to become the first "unstable" aircraft in the former USSR. Its aerodynamics would have to be determined completely by the capabilities of its quadruplex flight-by-wire control system. The growing importance of low-level penetration tactics dictated that the new fighter should be capable of look-down/shoot-down intercepts of aircraft and low-flying cruise missiles, while the increasing use of stand-off weapons made it necessary to track and destroy targets at very long ranges.

The design team was led by Yevgeny Ivanov supported by the bureau's General Designer Pavel Osipovich Sukhoi, replaced after his death in 1975 by the current General Designer Michail Petrovich Simonov. It's very interesting that after two years of preliminary work the basic layout of the aircraft was drawn up by only three men over a single weekend.

On the 20th of May 1977 the T101, built in its Moscow workshop, made its maiden flight in Zhukhovsky piloted by Vladimir Ilyushin, son of the famous aircraft designer, a Hero of the Soviet Union and test pilot of the Sukhoi OKB. The tests showed that the aircraft in general satisfied the requirements of the technical assignment. A batch of ten aircraft was ordered for development trials. However, it was soon established that the maximum flight range and manoeuvrability of the new aircraft did not surpass those of the best foreign equivalents. There were also problems with drag, flutter, engine performance and fuel consumption. In addition, the second prototype T102 crashed, killing its pilot. The research workers of the design bureau decided to substantially modify the aircraft. By 1981 an entirely new aircraft under the name of T10S was born and made its maiden flight on the 20th of April again flown by Ilyushin. This aircraft looked much more like the production Su27 we know today.

Tests showed that the designers had created a really outstanding aircraft having no equals in manoeuvrability, flight range and combat effectiveness. The Su27 included some radical innovations. The airframe was designed using a so-called "integral layout" with smooth fairings between the wings and fuselage. Due to the incorporation of advanced lightweight aluminiumlithium alloys, the airframe is light, if you consider its strength and sheer size. The wing was engineered using an ogival shape and wingroot extension. The wing, which has about 42° of leading edge sweep is vast but simple with full-span leading-edge flaps (slats) and trailing-edge flaperons. Occupying about two-thirds of each trailing edge the 4.9m^2 flaperons combine the functions of conventional flaps and ailerons and move in unison as flaps to provide lift and drag, or differentially as ailerons.

The Su27 is powered by two AL31F highly economical dual-flow turbojet engines designed by A. M. Lyul'ka, the MMZ Saturn General Designer. The AL31F engine is rated at 12500 kg static thrust in afterburner (when it consumes 1.92 kg of fuel per kg of thrust per hour) and at 7600 kg in military power (where fuel consumption drops to 0.75 kg of fuel per kg of thrust). Specific fuel consumption at cruise power is 0.67 kg/kg hour. With a TBO of 3000 hours the engine has proved to be reliable, robust and maintainable. The engine's most impressive feature is its tolerance to severely disturbed airflow, and its ability to go on running smoothly in extreme conditions, as demonstrated during the tail-slide and Cobra manoeuvres.

An indisputable strength is the aircraft's quadruplex fly-by-wire remote control system (Russian designation EDSU) with built-in angle of attack and G limiters. The aircraft employs a weapons control system using the RLPK27 (service designation) coherent pulse-Doppler jam-proof radar with track-while-scan and look-down/shoot-down capability. The radar has a maximum detection range of 240 km (149 miles) and a tracking range of up to 185 km (115 miles) and is able to simultaneously track up to 10 targets and provide simultaneous missile launch on two targets. The radar is backed up with the 36Sh electro-optical system (EOS) designed by the Geophysica NPO. The EOS combines laser rangefinder (effective range 8 km/5 miles) and Infra-Red Search and Track (IRST) (effective range 50 km/31 miles). The EOS or missile's seekers can be slaved to the pilot's helmet-mounted target designator allowing the pilot to target simply by moving his head.

The pilot sits on the Zvezda K36DM zero-zero ejection seat, which is also used on many other Russian combat aircraft, including the Buran space shuttle. The K36DM is capable of safe operation at all speeds from zero to 1400 km/h (870 mph) or Mach 2, and at altitudes from ground level to 25000 m (82,020 ft). In 1989, during Le Bourget air show it saved Anatoly Kvochur, the famous LII (Russian designation for the Flight Experimental Institute) test pilot from certain death, when his MiG29 ingested a bird into the starboard engine intake at about 300 ft and 250 km/h.

The serial production of Su27 began in the far eastern town of Komsomolsk-upon-Amur in 1982, and the first production aircraft entered service in the Air Defence and the Air Force units only in 1985.

In 1991 China bought twenty-four Su27s for $35,000,000 each. After the break-up of the USSR, new users of the Su27 appeared, most notably the Ukraine, Byelorussia and Georgia.

Between 1986 and 1988 the Su27 was modified with the aim of setting world records and assigned the name P42. This aircraft set 27 world records. These included time-to-height records to 3000, 6000, 9000, 12000 and 15000 m (9,843; 19,585; 29,528; 39,370 and 49,213 ft, respectively), a height record of 19335 m (63,435 ft), and time to height records with various payloads. In the summer of 1989 during the Paris Air Salon at Le Bourget the Su27 demonstrated for the first time the "dynamic deceleration" - a new manoeuvre named Pugachev's Cobra in honour of its first performer. In a sharp nose up movement the aircraft, weighing some 26 tonnes and flying at 450 km/h pitches up to 100° angle of attack decelerating to 250 km/h in 1.5 seconds and then returns to horizontal flight.

The Su27 became a base for development of many different versions. The following versions are known for the moment:

- Su27UB - two-seat combat trainer;
- Su27UP - two-seat combat patrol trainer for the air defence units;
- Su30 (Su27PU) - two-seat interceptor, optimised for long duration missions, with advanced "mini-AWACS" datalink option for group operations;
- Su32FN - side-by-side two-seat tactical bomber;
- Su33 (Su27K) - navalised version of the Su27;
- Su34 (Su27IB) - side-by-side two-seat fighter-bomber;
- Su35 (Su27M) - tactical multi-role fighter.

But all these superb aircraft will appear in the next story...

Technical Specification of the Su27

	Metric	**Imperial**
Length (w/o pitot head)	21.935 m	72 ft
Height	5.932 m	19.5 ft
Wingspan	14.7 m	48 ft
Wing sweep	42°	
Wing area	62 m^2	667 ft^2
Crew	1 officer	
Engines	2xTRDD AL31F turbofans	
Total thrust	25000 kg	55,115 lb
Fuel consumption (per kg of thrust per hour):		
full power	1.92 kg	4.23 lb
military power	0.75 kg	1.65 lb
cruise power	0.67 kg	1.48 lb
Top speed at sea level	1470 km/hour	794 knots
Top speed at 50,000 ft	2500 km/hour	1,350 knots
Maximum Mach	2.35	
Service ceiling	18500 km	59,000 ft
Dynamic ceiling	24000 km	78,800 ft
Maximum rate of climb	300 m/sec	960 ft/sec
Critical AOA	33°	
Max operational AOA	27.5°	
Maximum G-load	9.0	
Maximum rate-of-turn		
sustained	22.5°/sec	
instantaneous	28.5°/sec	

	Metric	Imperial
Maximum range	4000 km	2,160 nm
Empty weight	16000 kg	35,274 lb
Standard takeoff weight	22500 kg	49,603 lb
Maximum takeoff weight	30000 kg	66,138 lb
Maximum landing weight @ 3 m/s R.O.D.	22000 kg	46,300 lb
Internal fuel tanks capacity	9400 kg	20,723 lb
Takeoff run in afterburner @ 22500 kg TOW	500-700 m	1,476-2,297 ft
Landing run with parachute	620 m	2,034 ft
Landing speed @ 22500 kg	240 km/h	130 knots

Quick Start

To install, configure, and run the program you should refer to the separate Technical Supplement, which gives detailed description of these procedures for different kinds of hardware and operational environments (DOS, Windows, etc.). Once the program starts, you will find yourself within the Mission Editor. If you are impatient to find out just how good a pilot you are, it's time to plunge into Instant Action. To accomplish this, click **File** (or press **Alt+F**) on the menu bar at the top of the screen, then select **Open Mission.** From the dialog box select **"Training mission (*.mis)"** for the file type and **Free Flight** (the file *t_freef.mis*) or **Air Combat** (*t_a2a.mis*) for the mission title, depending on your wish. Press the **Run** button. Some seconds later you'll find yourself in the cockpit of the Flanker flying ahead and free from guns and adversaries or ready to dogfight with enemy fighters, respectively. In the second case, be ready to use your weapons against enemy aircraft. Enjoy yourself!

If you do want to go through all the stages of flight - from takeoff to landing - and train yourself in aerobatics without the risk of being attacked, choose the "Free take-off" training mission (*t_ftoff.mis*). You'll find yourself in the cockpit of the Su27 on the runway and ready to go.

Lower the flaps and slats (press **F**). Frankly speaking, this is a standard procedure but isn't obligatory. Throttle up to military power (100%) - press **PgUp** twice or push the throttle lever forward, or roll forward the throttle wheel on your joystick. Note that as standard procedure Russian pilots do not engage afterburners on take-off (unless the aircraft is heavily loaded, the runway is short, or the threat level high.

Accelerate to 250 km/h (check the number in the upper left-hand corner of the Head-Up Display), then smoothly pull back on the stick (or press the DownArrow key). The nose will rise smoothly.

Check attitude at 10-12° nose up on the HUD (the number to the left from the HUD centre). Let the aircraft accelerate in this attitude.

When the wheels have lifted off the runway and the rate of climb is positive, select GEAR UP (press **G**), and at an altitude of about 100 meters - FLAPS UP (press **F**). Have a nice flight!

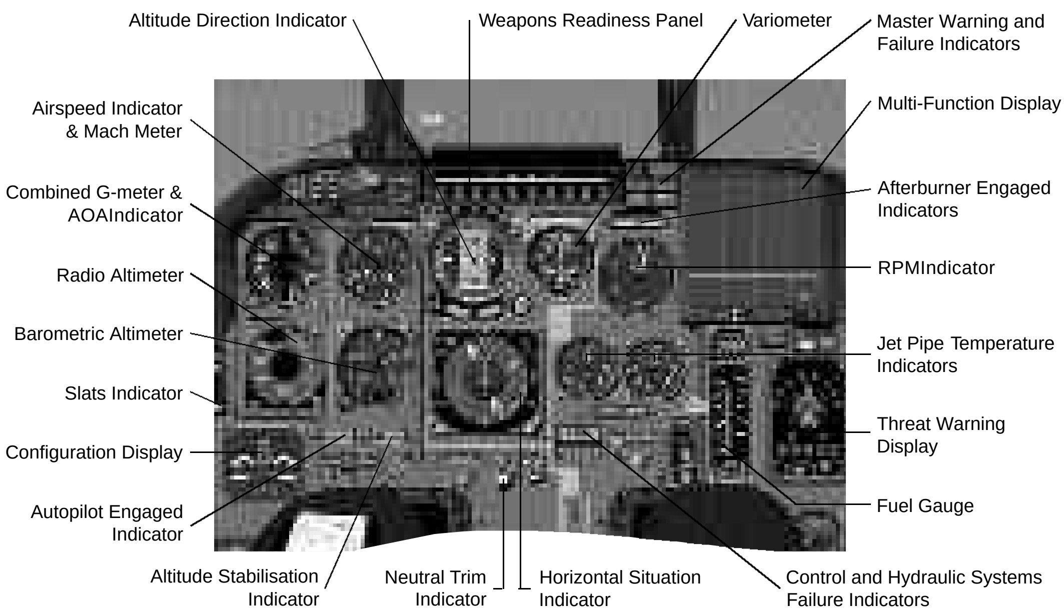
To have a look at your aircraft from outside, press **F2**. To return to the cockpit, press **F1**. You can also quickly finish your flight with the **ESC** key. Check the Function Key Card for more.

Chapter 2.
Inside the Cockpit

The cockpit of the Su27 can be divided into two main sections: the Instrument Panel and the Head Up Display (HUD). The panel contains most of the flight instruments. The HUD displays the main navigational and combat information; its detailed description is given below in a separate section. A number of indicators, buttons and levers, including the Throttle Lever, are located on the side panels of the cockpit, but this manual does not describe them because of their unimportance to this package.

Instrument Panel

Use the Numeric Keypad to move your head around. A front view of the Instrument Panel (pilot's head is lowered down) is shown in the figure below. The layout of the instruments, controls and their operation almost completely correspond to those of the real Flanker.



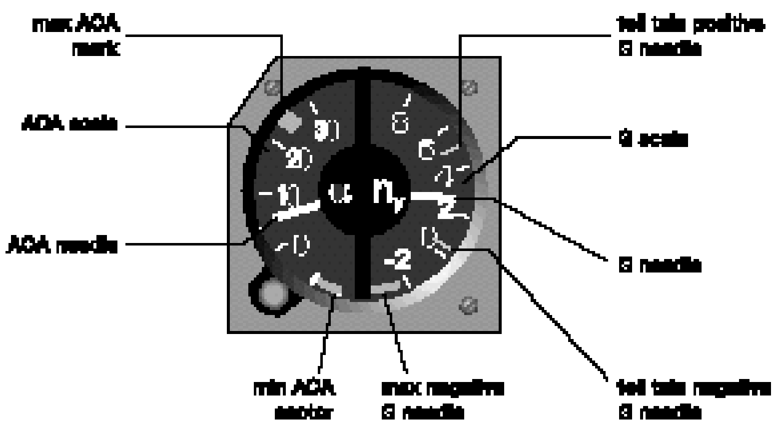
Let's consider the main instruments located on the forward panel.

Weapons Readiness Panel

This indicator is located just below the HUD and shows the location and readiness of the available weapons hanging on 10 underwing and fuselage pylons. The illuminated lights in the upper row (green) indicate the presence of weapons on the pylons, and those in the lower row (yellow), the readiness of the corresponding weapons to instant use. Note that such readiness is governed not only by the selection of the weapon, but also by the specific combat situation.

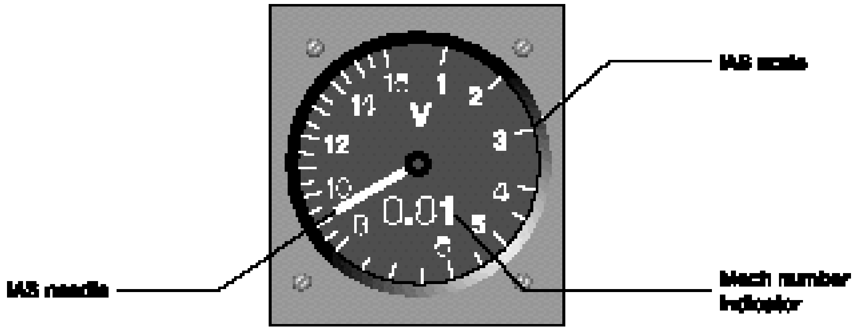
Combined G Meter& AOA Indicator

This instrument is located in the upper left corner of the Instrument Panel. The scale of the AOA Indicator (left side of the instrument) has uniform marks in the range from 20˚ to 40˚. The red mark on the scale marks the maximum operational angle of attack - 27.5˚ (the critical AOA for the Su27 is 33˚). On the right side of the instrument is the Gs scale uniformly marked every 2 Gs from 4 to 10. The aircraft is limited by 3 and +9 Gs. Two shorter tell-tale needles are visible on the right inner rim of the Gs scale. They show the maximum positive and negative Gs you have pulled since takeoff.



The instrument readings in the above figure show an AOA of 5 degrees and G-load of 2.5 Gs.

Airspeed Indicator & Mach Meter (ASI)



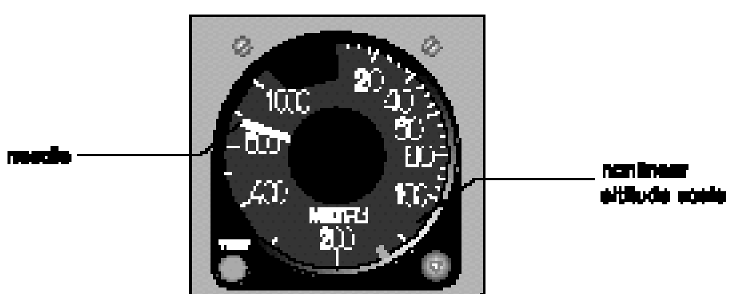
The ASI is situated to the right of the G Meter and gives information on the current indicated airspeed and Mach number.

Indicated airspeed (IAS) is determined by the value of dynamic pressure experienced by the aircraft moving through the air. At sea level indicated airspeed is exactly the same as the true airspeed of the aircraft's motion relative to the air it is flying through. However, if the true airspeed remains constant with an increase in your altitude, indicated airspeed decreases since outside air density drops with altitude. This means that to maintain level flight at higher altitudes requires increasingly higher true airspeeds (at a constant AOA). Indicated airspeed is very important for showing when the aircraft is about to stall, as it has direct relation to the airflow over the wings.

The scale of the ASI is marked from 0 to 1600 km/h and is non-linear (the values of the scale divisions grow with increase in speed). The three-digit Mach number indicator reflects the ratio of true airspeed to the speed of sound under the given flight conditions.

On the figure above the instrument shows an IAS of 900 km/h and Mach 0.81

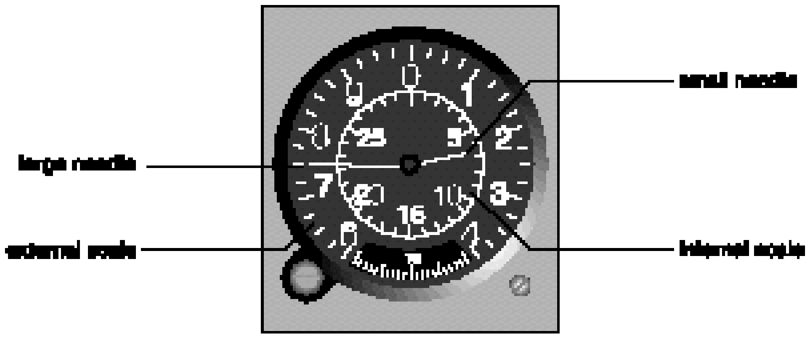
Radar Altimeter



The Radar Altimeter is right below the Combined G Meter & AOA Indicator. It indicates the aircraft’s altitude in meters above ground level (Russian designation **МЕТРЫ** on the instrument is pronounced 'met-ree' and denotes METERS). The scale of the instrument is marked from 0 to 1000 meters and is non-linear (the lower the altitude the larger the division).

The reading of the Altimeter in the figure above corresponds to an altitude of 700 meters above ground level.

Barometric Altimeter

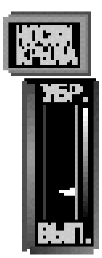


This indicator is below the ASI, and it measures the aircraft's barometric altitude, which is based on the difference between outside air pressure and air pressure at sea level. The small needle moving along the internal scale of the instrument shows your barometric altitude in the range from 0 to 30 km. The external scale is marked every 100 meters in the range from 0 to 1000 meters.

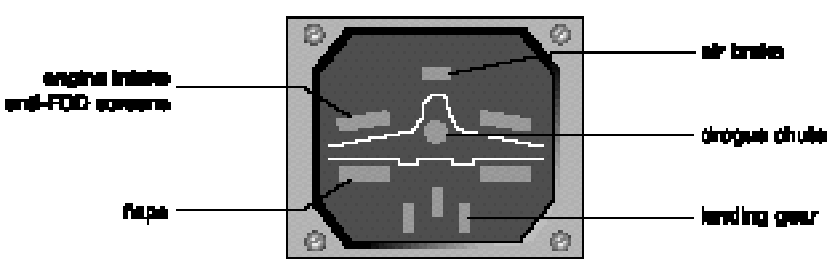
Here the reading on the internal scale corresponds to 6 kilometres and that on the external scale to 750 meters, which gives a total altitude of 6750 meters.

Slats Indicator

The Slats Indicator is to the left of the Radio Altimeter. The white needle on the black bar indicates the position of the leading edge flaps also known as slats. The lower the needle is, the further the slats are deployed ('**ВЫП**'). Note that the slats on the Flanker are engaged automatically, when the aircraft needs extra lift (for example, when performing a hard turn or landing).



Configuration Display



In the lower left-hand corner of the Instrument Panel below the Radar Altimeter is the Configuration Display. It shows information about the positions of the landing gear, flaps, anti-FOD screens, air brake and drogue chute. Illumination of any indicator by a green light means that the corresponding control is in the active position, i.e. enabled. A flashing green light means that the control is in movement.

The anti-FOD screens are automatically actuated on take-off and landing.

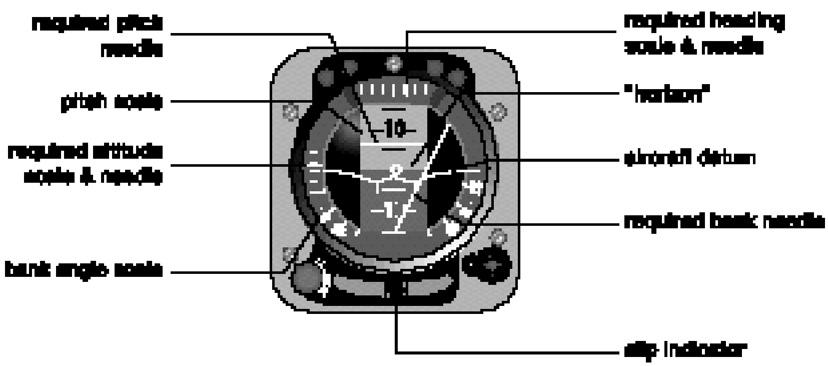
Autopilot Engaged Indicator

Illumination of this indicator located to the right of the Configuration Display indicates operation of the Automatic Control System in autopilot mode. Russian designation '**АВТО**' (pronounced 'af-to') denotes AUTO. The autopilot is toggled by the **A** key.

Altitude Stabilisation Indicator

The Altitude Stabilisation Indicator is to the right of the Autopilot Engaged Indicator below the Barometric Altimeter. It's illumination denotes that the Automatic Control System is in altitude stabilisation mode. Russian designation '**Н стаб**' is pronounced 'ash-stab'. Altitude stabilisation mode is toggled by the **H** key.

Attitude Direction Indicator (ADI)

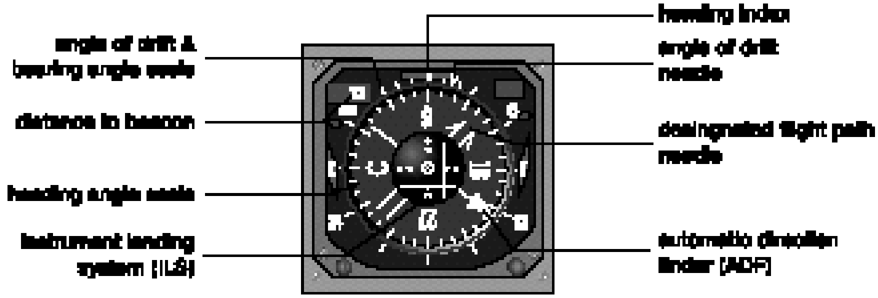


In the centre of the Instrument Panel just below the Weapon Readiness Indicator is the Attitude Direction Indicator (ADI) or *artificial horizon*. It is the main navigational instrument, especially in zero visibility conditions.

The mobile Pitch Scale and the Aircraft Datum (symbolic image of the aircraft in the centre) show the aircraft's spatial orientation with respect to the horizon. The ADI also receives control information on the required pitch angle, bank, heading, and altitude. This information is supplied by the navigation system and it enables the pilot to manually fly the Flanker and follow a specific flight plan.

The readings of the instrument in the above figure show that the aircraft is flying pretty much straight and level. However, the Required Bank Needle and the Required Heading Needle indicate that the pilot should turn right. Furthermore, the command Pitch Needle and the Required Altitude Needle indicate that the pilot should pitch up slightly and gain some altitude.

Horizontal Situation Indicator (HSI)



In the lower central part of the Instrument Panel just under the Attitude Direction Indicator is the main navigational instrument - the Horizontal Situation Indicator (HSI).

Using the rotating heading scale and the fixed heading index at the top of the instrument, the pilot reads the aircraft’s heading (here, 90˚ or due East). Marks on the scale are in increments of 10 degrees. The 'C' character on the heading scale stands for North in Russian; '9' corresponds to 90˚ (East), '18' to 180˚ (South), and '27' to 270˚ (West). The Automatic Direction Finder or ADF aids in guiding the aircraft to a waypoint (a radio beacon). When the narrow arrow and the fixed heading index are aligned, the aircraft is flying precisely in the direction of the current radio beacon (in the absence of wind). The number in the upper left-hand corner of the HSI shows the distance to the current waypoint (in kilometres).

The navigation system controls the position of the designated flight path needle (wide arrow), which indicates the required flight trajectory. This can be important, if your flight plan has been designed to avoid threat zones, such as enemy radar and SAM sites. When you follow your flight plan in On-route Mode, the designated flight path indicator shows the bearing from the previous to the current waypoint, and in Landing Mode, the runway heading. When the designated flight path needle and the ADF needle are aligned and vertical (pointing up towards the heading index), this means that your aircraft is on track on the correct heading to the next beacon.

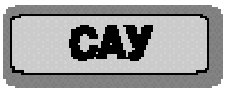
The two small bars in the centre of the instrument are the Glide Slope Deviation (GSD) Bar and the Localiser Deviation (LD) Bar. The GSD Bar measures your vertical deviation from the glide path, the LD Bar - your offset from the runway centreline. They correspond in Western aircraft to the standard Instrument Landing System (ILS). On both the vertical and the horizontal scales each mark represents 2 degrees. In the above figure the aircraft is above and to the left from the glide path. This means that in order to return to the optimal glide slope and centreline the pilot should lower the nose slightly and turn slightly to the right.

The angle of drift needle moving along the short scale near the heading index reflects the influence of wind on the aircraft's lateral motion. In the presence of wind, the airspeed of the aircraft relative to the ground, that is, ground speed, differs from true airspeed (TAS) by the "value" of wind speed.

Wind blowing from any angle other than that of the aircraft heading or 180˚ reciprocal causes the aircraft to drift from the flight path. The angle between the true airspeed vector and the ground speed vector is known as an *angle of drift*. This navigation system computes the amount of the aircraft's drift and indicates the degree of heading correction required. So, to fly in the direction of a radio beacon in the presence of wind, it is necessary to align the ADF needle with the angle of drift needle rather than with the heading index

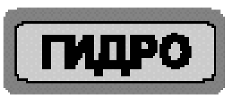
The readings of the instrument in the figure above correspond to a heading due East (90˚) with an angle of drift of 15˚ right. The next beacon is at 215˚, and the distance to the beacon is 23 km. The designated flight path indicator shows a heading of 135˚.

Automatic Control System Failure Indicator



The illumination of the ACS Failure Indicator (Russian designation '**САУ**' pronounced 'sau', stands for Automatic Control System) located to the right of the HSI signifies a failure of the Automatic Control System. This indicates a disturbance and/or failure in the operation of Autopilot and Altitude Stabilisation systems.

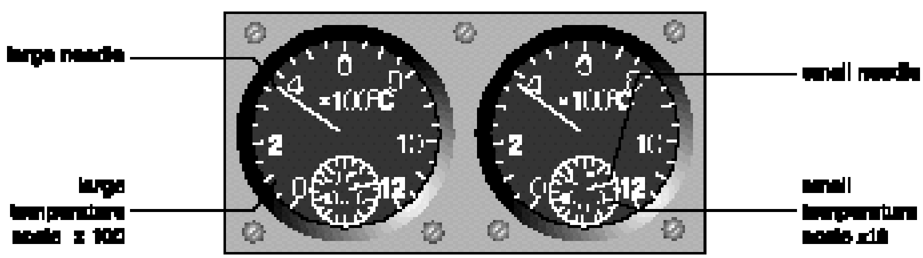
Hydraulic System Failure Indicator



The Hydraulic System Failure Indicator (Russian designation '**ГИДРО**' pronounced 'gid-ro', stands for HYDRO) is just below the ACS Failure Indicator. When the hydraulic booster system fails, this indicator lights up. This kind of failure results in the loss of control of the flaps, slats, and the air brake, plus diminished authority of elevator, rudder and flaperons.

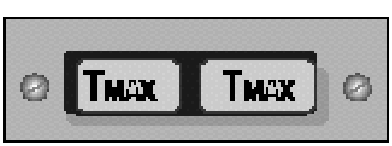
For more information on systems failures read Chapter 7, "Warnings and Failures".

Jet Pipe Temperature Indicators



The two indicators located to the right of the HSI show jet pipe temperature of gases at the turbine exhaust of both AL31F engines. Each indicator consists of two circular scales, the large scale ranging from 0 up to 1000˚ Celsius and showing the temperature in hundreds of degrees. The small scale renders more precisely the reading taken from the large scale and has the range of 100˚C in tens of degrees. In the figure above the gauges show 300˚C on the large scale, and 70˚C on the small one. Therefore, the temperature value is 370˚C.

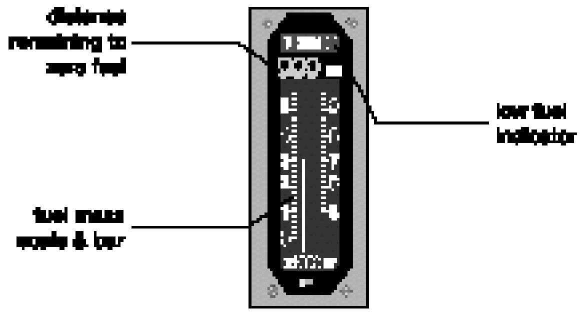
Maximum Engine Temperature Indicators



Located just below the Jet Pipe Temperature Indicators, the Max Engine Temperature Indicators of the port and starboard engines warn the pilot about critical jet pipe temperatures, resulting from engine failure, fire, compressor failure, missile strike, etc.

A failure of the power plant leads to a spontaneous increase of gas temperature at the turbine exit and a drop in RPM. This situation is immediately reflected on the RPM Indicator and the Jet Pipe Temperature Indicators. An engine on fire or suffering catastrophic failure will shut down and release a powerful halogen extinguisher automatically. To learn how to fly and land the aircraft with one engine out, turn to Chapter 7, "Warnings and Failures".

Fuel Gauge

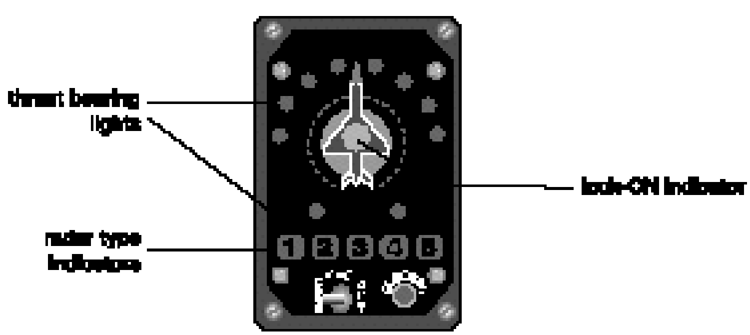


The Fuel Gauge is to the right of the Jet Pipe Temperature Indicators. It indicates total fuel remaining in the tanks. The vertical scale of the instrument is marked in tons in a range from 0 to 9 tons (the scale for the range from 5 to 9 tons is to the right of the main scale).

Above the scale is the zero fuel counter. The figures displayed on the counter show the range in kilometres, for the remaining fuel. The distance is calculated with the assumption that the engines will operate at close to the optimum cruise power setting. If distance exceeds 1000 kilometres, the counter reads '999'.

At the top of the Fuel Gauge is the '**ТОПЛИО**' light (denotes 'fuel' in Russian, should be pronounced 'top-li-vo'). When this is highlighted, you are on your reserve fuel, and it’s definitely time to return to base as things could be going awfully quiet soon. Don't panic too much as the reserve guarantees successful flight to the nearest diversion airfield in case a landing is impossible on the initial airfield (runway destroyed, poor visibility, etc.).

Threat Warning Display



In the lower right-hand corner of the cockpit is the Threat Warning Display (TWD). It depicts information on enemy illumination sources detected by the SPO15 'Beryoza' Radar Warning System. Such sources can be enemy aircraft, radar of SAM installations, AWACS, and so on. Lights surrounding the aircraft's silhouette show the approximate bearing of the illumination source:

if the aircraft falls within radar coverage, the corresponding light flashes at a frequency characterising the periodicity of illumination, and the audio alarm beeps.

In the event of a "lock on" the flashing light indicating direction changes to permanent. Then the red Lock-On Indicator is illuminated, the aircraft silhouette being highlighted.

In the lower part of the TWD are 5 lights indicating the type of radar that has locked onto your aircraft. The Radar Warning System provides for the identification of the following types of radar:

1 - airborne radar;

2 - radar of a long-range SAM system;

3 - radar of a mid-range SAM system;

4 - radar of a short-range SAM system;

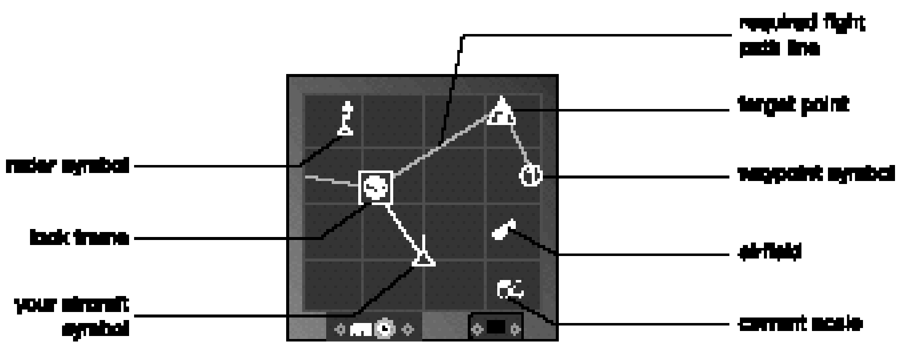
5 - early warning radar (airborne or ground-based).

How to react to the information displayed on this indicator, turn to Chapter 8, "Understanding SAMs and Countermeasures".

Multi-Function Display

In the upper right-hand corner of the Instrument Panel is the Multi-Function Display (MFD). Information displayed on the MFD depends on the current mode of the navigation and weapons systems. Let us consider the main types of MFD screen symbology in navigation and combat modes.

Navigation mode

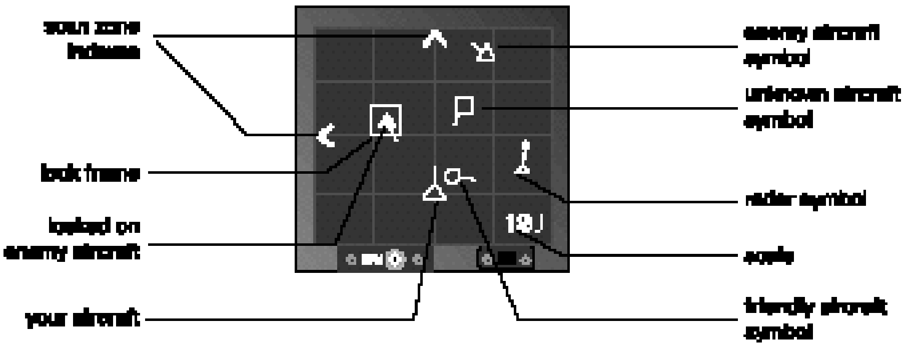


The small fixed triangle below the centre of the MFD is your jet. The MFD displays information in a co-ordinate system bound to your aircraft. Your flight plan is displayed as a polygonal line connecting waypoints displayed as circles with waypoint order numbers inside. The position of each friendly airfield (or airbase) is displayed on the MFD as a solid bar, oriented in the direction of the available runway.

A square frame (the lock frame) encloses the symbol of the current waypoint or airfield. In the above figure waypoint 3 is current. In the lower right-hand corner of the display is the scale information - the number of kilometres along both dimensions on the MFD (in the above figure the MFD displays an area of 64x64 kilometres).

Besides the navigational information, the MFD shows sources of illumination detected by the Radar Warning System as a radar symbol (lightning).

Beyond-visual-range (BVR) mode



In BVR mode, the MFD shows targeting information taken from your radar and/or an AWACS aircraft. Targets provided by an AWACS station or ground-based Early Warning Radar (EWR) station are displayed as non-filled symbols while those detected by your onboard radar are always solid. Note that if your radar can see a target provided by AWACS the target will be displayed solid. The scale of displayed information is shown by the figure in the lower right-hand corner of the display (here, 128x128 km).

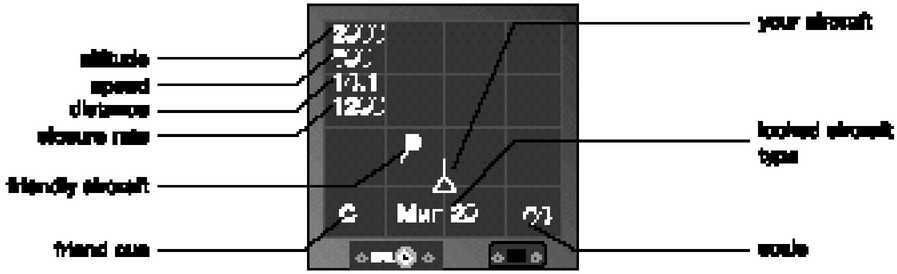
The MFD in the above figure shows three aircraft and one radar provided by an AWACS aircraft or EWR station. Besides, one enemy aircraft (the solid triangle) is seen by your onboard radar which has locked onto it (see the lock frame around the aircraft symbol). The small circle is a friendly aircraft ("friend"). The empty triangle is are enemy aircraft ("bandit"). The square represents an unknown aircraft ("bogey"). A dash, emerging from a target symbol, shows the direction of the target’s motion. The radar symbols show the position of radar illumination sources detected by the Radar Warning System.

The characters '<' and '^' on the left rim and the top of the display are movable scan zone indexes. They indicate the position of the scan zone centre of your radar or electro-optical system (EOS) in relation to the aircraft. For example, the higher the '<' index on the MFD, the higher your radar or EOS scans. Likewise, the more the '^' index is shifted to the left, the farther left the scan zone centre lies from the longitudinal axis of your aircraft. The positions of the indexes are scaled to the size of the radar scan zone (120˚x120˚) or of the EOS scan zone (75˚x120˚).

Close Air Combat (CAC) mode

In this mode the MFD gets information from your radar, the EOS, and the RWS. Information in this mode is similar to that for BVR mode, except that the scan zone indexes cannot be moved, therefore these are not presented on the MFD. Again, the scale of displayed information is shown in the lower right-hand corner of the display.

Track mode



A target, locked on and being tracked, appears on the MFD as a triangle ("foe") or as a circle ("friend") with a dash showing the direction of the target's motion. If your radar or EOS is tracking a friendly target, the friend cue '**С**' (for '**Свой**' in Russian, which means 'ours') is displayed in the lower left-hand corner of the display.

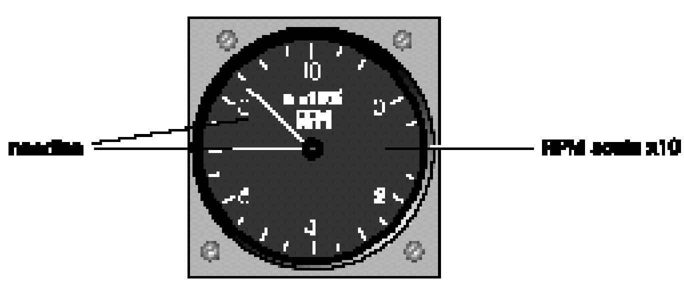
The target type designation (the name of the identified aircraft) is displayed just beneath the symbol of your aircraft. In the above figure the target is identified as the **'Миг-29'** (**MiG-29**) and is friendly ('**С**').

The information about the locked target in the upper left-hand corner of the MFD includes the following target data:

- altitude (meters)
- airspeed (km/h)
- distance to target (km)
- closure rate (km/h).

In our case, the altitude and airspeed of the friendly aircraft are 2900 meters and 690 km/h respectively, the distance to the target is 14.1 km, and the closure rate is 1290 km/h. The MFD scale is shown in the lower right-hand corner (64 km).

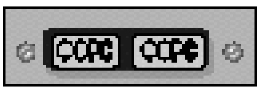
RPM Indicator



The RPM Indicator is located to the left of the MFD. The scale of the indicator is graduated from 0 to 110% in tens of percent. The port and starboard engine thrust is indicated by independent needles.

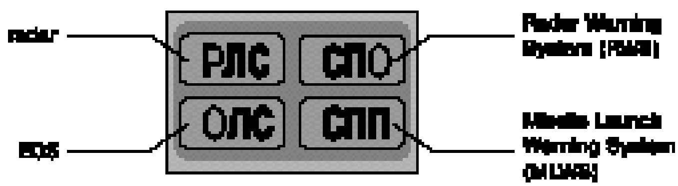
Percentage	Thrust rating	Russian designation	Pronounced
0%	zero thrust	**СТОП**	'stop'
67%	ground idle	**МАЛЫЙ ГАЗ** (**МГ**)	'malyi gaz'
75%	flight idle	**ПМГ**	'pe-em-ge'
100%	military power	**МАКСИМАЛ**	'maximal'
105%	min afterburners	**МИНМАЛЬНЫЙ ФОРСАЖ**	'minimalnyi forsazh'
110%	full afterburners	**ПОЛНЫЙ ФОРСАЖ**	'polnyi forsazh'

Afterburner Engaged Indicators



The Afterburner Engaged Indicators are right above the RPM indicator. They are highlighted when your RPMs are more than 100%. The words '**ФОРС**' on the indicators should be pronounced 'fors' and denote 'afterburners' in Russian.

Systems Failure Lights

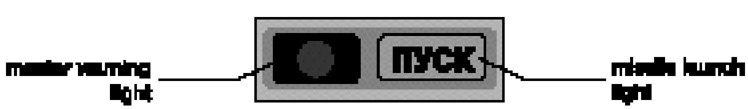


Four lights located between the Weapons Readiness Panel and the MFD warn you about failures of special systems:

- Radar ('**РЛС**', pronounced 'er-el-es');
- Electro-Optical System ('**ОЛС**', pronounced 'ols');
- Radar Warning System ('**СПО**', pronounced 'es-pe-o');
- Missile Launch Warning System ('**СПП**', pronounced 'es-pe-pe').

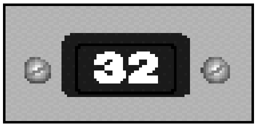
For more information on failures, turn to Chapter 7, "Warnings and Failures".

Master Warning & Missile Launch Light



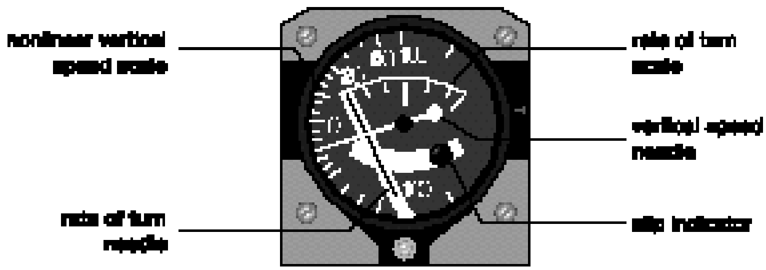
Just above the Systems Failure Lights are the Master Warning Light and the Missile Launch Light '**ПУСК**' (which means LAUNCH in Russian, pronounced 'pusk'). The flashing of the red Master Warning Light accompanied by beeps, attracts the pilot's attention to vital information such as ground proximity, stall, damage to any systems of the aircraft, low fuel, illumination of your aircraft by radar and others. For more information on possible warnings refer to Chapter 7, "Warnings and Failures".

Chaff/Flare Counter



Below the MFD next to the Fuel Gauge is the Chaff/Flare Counter, which shows how many APP50 combined chaff and flare dispensers remain at your disposal. The initial value of the counter is 32. The counter reads zero if the chaff/flare deployment system is damaged or you've run out of dispensers. To learn more about the chaff/flare deployment, read Chapter 8, "Understanding SAMs and Countermeasures".

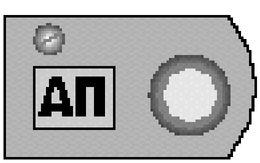
Variometer



The Variometer is situated between the Attitude Direction Indicator and the RPM Indicator and shows your rate of climb. The scale of the instrument is non-linear ranging from 200 m/s (climb) to 200 m/s (dive). Thus, in the area of zero vertical speed the scale has the highest accuracy. In the above figure the instrument shows a descent at 10 m/s.

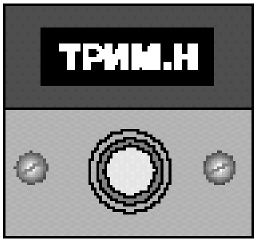
Besides the indication of vertical speed, the instrument shows your rate of turn and rate of slip. The rate of turn scale ranges from 3˚/sec left to 3˚/sec right with a 1degree interval. The deflection of the rate of turn needle to the left as shown in the above figure means that the aircraft is turning to the left. The small ball on the sideslip scale slides in the direction of the aircraft's sideslip. In the above figure the ball has slid to the right and is showing that the aircraft is sideslipping to the right.

Active Jamming Indicator



To the right from the Chaff/Flare Counter is the Active Jamming Indicator '**АП**' (pronounced 'ape', which stands for Active Jamming in Russian). This indicator shows activity of the built-in and/or additional Sorbtsiya active jamming system. If the indicator is not highlighted, your active jamming system is damaged or turned off. The active jamming system is toggled by the **E** key.

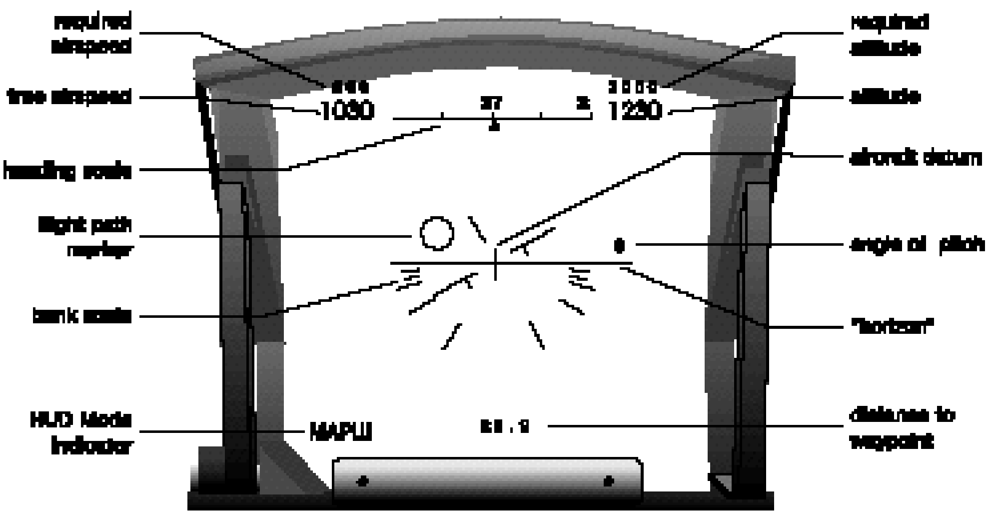
Neutral Trim Indicator



This indicator is located right below the Horizontal Situation Indicator. The highlighting of the Neutral Trim Indicator means that the trimmer is in the neutral position. As soon as you start to trim using the joystick coolie hat or the arrow keys, the light is disabled.

Head up display (HUD)

Among the most important multi-function instruments of the Flanker is the Head-Up Display (HUD) located in front of you. Information displayed on the HUD depends very much on the navigation or combat mode you are using, though some indications are common to many modes. The figure below shows the HUD in On-route ('**МАРШ**') submode of the Navigation Mode



True Airspeed

The true airspeed indicator is located in the upper left corner of the HUD and shows the aircraft’s current true airspeed (TAS) in km/h (unlike the IAS Indicator on the Instrument Panel, which displays indicated airspeed). In some HUD modes such (On-route, Return and Landing), a number in a smaller font is displayed above the true airspeed indicator. This number indicates the airspeed planned or required for the particular phase of flight.

Altitude Indicator

The altitude indicator is located in the upper right-hand corner of the HUD and shows the aircraft's barometric altitude. If the number is followed by the 'P' character (which means 'R' in Russian and stands for Radio) this means that your altitude is indicated by the Radar Altimeter rather than barometric one, which normally takes place at heights lower than 500 meters. Again, in On-route, Return, and Landing mode a number in a smaller font is displayed above the altitude indicator. This indicates the altitude planned or required for the particular phase of flight.

Heading Scale

The heading scale is located at the top of the HUD and is marked in tens of degrees. The triangle mark below the centre of the scale shows your heading. If the HUD is damaged you can also read the heading from the Magnetic Compass in the upper-right corner of the cockpit.

Aircraft Datum

The aircraft datum (aircraft silhouette in the centre of the HUD) is displayed around the HUD centre datum (a small cross), and it shows the orientation of your aircraft relative to the horizon. A line representing the artificial horizon is displayed below or above the aircraft datum with the angle of pitch indication to the right.

Bank Scale

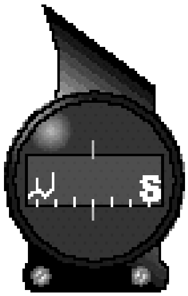
A half-circle with rays beneath the aircraft datum is the bank scale, which indicates the aircraft's bank angle.

HUD Mode Indicator

The HUD Mode Indicator shows the navigation or combat mode you are using. Possible designations are:

Designation	Mode	Purpose
НАВ ('nav')	Navigation	Basic navigation mode, heading + stopwatch
МАРШ ('marsh')	On-route	Follow flight path
ВОЗВ ('vozv')	Return	Return to selected airfield
ПОС ('pos')	Landing	Land on selected airfield. ILS approach
ДВБ ('de-ve-be')	Beyond Visual Range (BVR)	Engage airborne targets at long ranges
БВБ ('be-ve-be')	Close Air Combat (CAC)	Dogfight at visual range
ЗЕМЛЯ ('zem-lja')	Air-to-Ground (A2G)	Destroy ground targets
ФИО ('fee')	Longitudinal missile aiming	Aim using missile guidance system at visual ranges
ШЛЕМ ('shlem')	Helmet	Engage agile targets using helmet-mounted target designator

Magnetic Compass



The forward frame of the cockpit canopy houses three rearview mirrors and the Magnetic Compass. The compass consists of a ball with a scale, which is enclosed in a casing and plunged in a liquid. The scale on the ball is marked in 30˚ increments and has designations of the cardinal points (North, West, South and East).

Chapter 3.
Piloting the Flanker

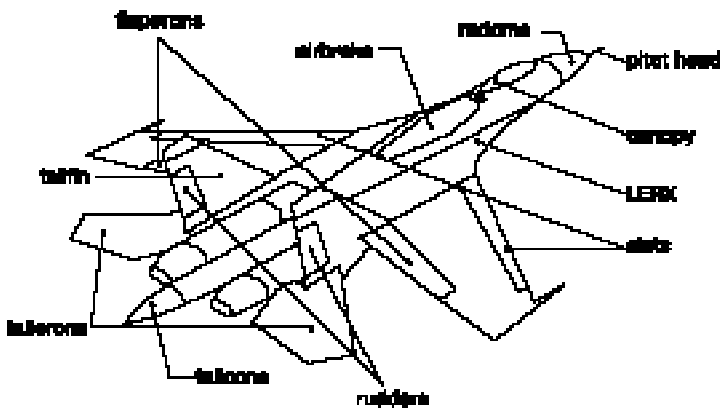
If you have no flight simulator expertise or if you have any difficulties piloting the Su-27, this chapter is just what you need. In the long run, the success of air combat largely depends on basic piloting skill. In this chapter we'll not take too close a look at the theory of flight, but we shall give you the minimum of information necessary to understand the terminology and the description of techniques and nuances of piloting.

Basic Aerodynamics

Prior to describing piloting technique, we shall touch briefly on elementary information relating to flight and control of the aircraft. If you are closely acquainted with the theory of flight and general aircraft design, skip this section.

Su-27 external controls

Aircraft motion is determined by its thrust and aerodynamic control system. The Su-27 benefits from a superb “integral” airframe characterised below.



The differential stabilisers or *tailerons* are located to the rear of the aircraft to the left and right of the engine nacelles. If you deflect both differential stabilisers in the same direction by pushing the joystick forward or pulling it back, they function purely as pitch controls (deflection limits are ±10°). Add left or right input to the joystick and they function as roll controls that are combined with the main roll controls, the differential flaps, or *flaperons* which occupy about two-thirds of the trailing edge of each wing. The flaperons function as usual flaps, if moved in unison, to provide extra lift and drag for takeoff and landing, and as ailerons if deflected in opposite directions. Travel is from 35° to -20°. To toggle the flaps manually, press the **F** key. If you want to lower the flaps and you don’t remember whether they are up or down, press **Shift+F**. To definitely select FLAPS UP, press **Ctrl+F**.

The full-span leading-edge flaps, or *slats*, are automatically-driven. They provide extra lift when manoeuvring and during takeoff and landing.

Two rudders are located in the rear part of the vertical tailfins. Rudder deflection is achieved by movement of the rudder pedals or by pressing the **Z** and **X** keys for left and right leg, respectively. Right rudder input will make the aircraft yaw smoothly to the right and will also induce a slow roll effect to the right. Notice that the same pedals are used on the ground to taxi. If you wish to block the rudder in a specific position then press down the key of the opposite rudder and hold down both the rudder keys. Check the rudder position on the HUD (press **Ctrl+J** to toggle the joystick and rudder position indication).

The *air brake* is used to reduce airspeed quickly during manoeuvres or during landing to reduce pitch angle on approach and the length of a landing run. It is located on the upper fuselage, and in the closed position stays flush with the surface. When deflected open (by pressing the **Shift+B** keys), the air brake extends outward and creates additional resistance to airflow. The airbrake should be deployed at least 2 km before touchdown. To retract the airbrake, press **Ctrl+B**. Note that you can also toggle the airbrake with the **B** key.

The long tailcone projecting aft from between the engine nacelles reduces drag and serves as a location for the braking parachute, or *drogue chute*, antennas and 32 chaff/flare dispensers.

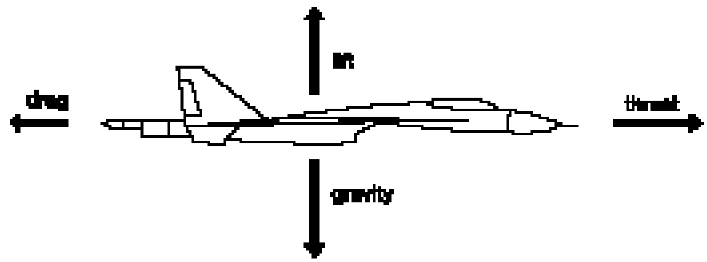
The wing is about 42° of leading edge sweep and 2.5° anhedral. The long flaring ogival-shaped wing *leading-edge root extensions* (called LERXes in the West and 'sabres' in Russia) generate lift forward of the centre of gravity, providing an increased nose-up pitching moment, which is more efficient at high AOAs. LERXes destabilise the aircraft in pitch, increasing agility.

In order to obtain its high level of manoeuvrability the Su-27 is designed to be longitudinally statically unstable. That means that if the aircraft was flown manually, it would immediately begin to oscillate in pitch, and the oscillation would rapidly become too great to rectify (this can be compared to steering a bicycle backwards). That is why it was necessary to equip the aircraft with a computerised flight control system (FCS). For the Su-27 this system designated SDU-27 (SDU stands for Remote Control System in Russian) combines conventional hydro-mechanical controls for the rudders, flaperons and differential taileron movement with a quadruplex fly-by-wire (FBW) control of taileron movement for control in pitch. The FBW system also provides stability augmentation in roll and yaw. The system uses four computer-controlled channels for control in pitch and three channels for control in roll and yaw. Each computer is fed by a separate data source.

The FCS also performs as a G and angle-of-attack (AOA) limiter (see the explanation below in this chapter). "Soft" limits for the Su-27 are from +8.5 to -2.5 Gs and an operational AOA of 27.5°. The pilot can switch off the limiter or use extra stick force (about 15 kg) to pull through the stick stops. This is how manoeuvres like the famous Cobra are performed. Of course, you cannot add extra force to your joystick at home and there are no built-in stops; however, you will be able to execute the Cobra in our simulation.

Flight dynamics

In level flight the aircraft moves without roll and yaw at a constant altitude. Four forces, shown in the figure below, act on the aircraft as it moves through the air.



Thrust

Thrust is the aerodynamic force which propels aircraft through the air. The Su-27's AL-31F turbofans produce total thrust rated at 25000 kg in afterburner and 15200 kg in military power.

Lift

Lift is the force that allows aircraft to stay in the air. When air moves over the wing, the air speed above the upper arched surface of the wing is higher than under the more flat lower surface of the wing. This is because the air above the wing has to travel faster to meet the air flow under the wing at the trailing edge of the wing. In accordance to aerodynamic laws, the faster the air speed, the lower the pressure. This means that the air pressure above the wing drops while the pressure under the wing remains normal. This difference in air pressure produces a force called *lift* acting in the direction of the low pressure area, that is, towards the upper surface of the wing. Therefore, the faster air moves over the wing the greater the lift.

Lift also depends on the angle at which the wing moves through the air, this angle is known as the Angle Of Attack (AOA). The greater the AOA, the greater the force of lift. However, at high angle of attack the air flow over the wing surfaces can start to break up, which can result in a stall (we'll discuss this later). That is why the Su-27's critical AOA is 33° (though the operational or "soft" limit is 27.5°). These limits are controlled by the FCS which can be disabled when performing the Cobra since during this manoeuvre the AOA reaches 100°.

Gravity

Gravity is the force that attracts an aircraft (and any other object) to the ground. To fly at a constant altitude gravity should be balanced by the aircraft’s lift. If something upsets this balance, excess lift will cause the aircraft to climb, and excess gravity will cause it to descend.

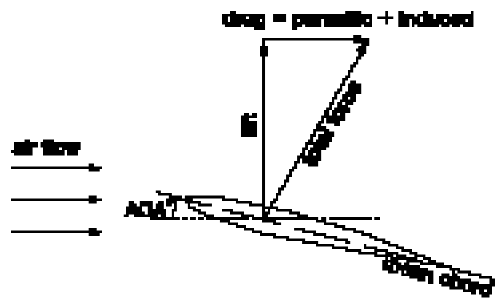
Gravity is measured in Gs. One G is equal to the normal force of gravity acting upon aircraft flying straight and level, thus, 5 Gs would be a force equal to five times the normal force of gravity. This can happen if you pull a hard turn, when centrifugal force adds more gravity to your aircraft. Such increased gravity is called G load or G. As you pull more Gs, your weight increases correspondingly. This means that at 5 Gs your head, for example, weights 5 times the ordinary.

Note that high Gs may result in the pilot's loss of consciousness. If you experience G loads acting in the direction from your head towards your feet (positive Gs) the blood leaves you head. In so doing, your vision will lose colour, and finally everything will go black - the screen will fade to black this is known as *blackout*. If you pitch down hard from level flight your weight will lessen. At some moment your body will weigh nothing, i.e., you'll be experiencing 0 Gs. If you go on pitching down you'll experience negative Gs, when the blood rushes to your head. When you push -2 or -3 Gs everything turns slightly red (in the pilot's eyes and on the screen). This condition is known as *redout*. The human body can stand up to 9 positive Gs without severe consequences, however, the limit for negative G-load is only 5 Gs. When catapulting from the aircraft the pilot can even experience up to 20 Gs, but since this lasts only for some tenths of a second no injury is suffered. The longer you hold high G-loads, the harder it becomes to resist blackout/redout and the faster your body tires.

The FCS of the Su-27 limits positive and negative Gs to +8.5 and -2.5, respectively. However, the aircraft can be flown to +9 and -3 Gs and has structural design limitations of +15 and -5 Gs.

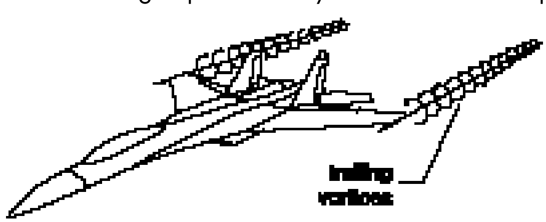
Drag

Drag is the resistance to the forward movement of the aircraft. The amount of drag depends on many factors: a difference between pressures on the leading and trailing edges of the wing, air viscosity and the arrangement of weapons on the aircraft's pylons (friction drag, or *parasitic* drag), as well as on the lift and AOA (*induced* drag).

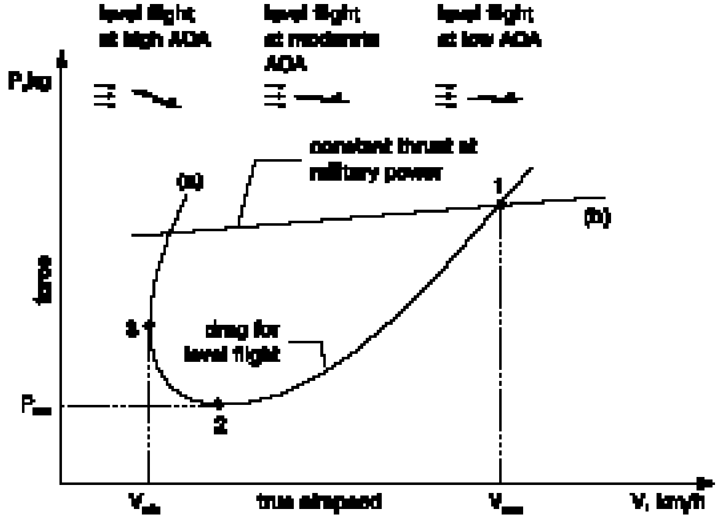


Parasitic drag is a function of a particular aircraft's size and shape and is a major concern of aircraft designers. Normally, the greater the frontal area of the aircraft, the higher the drag.

Induced drag is produced by lift and is bound up with the forming of vortices on the wingtips (turbulence), which produce extra drag. The generation of vortices is caused by the air flow from the lower surface of the wing to the upper one over the wingtip. The higher the AOA (and hence lift), the greater intensity of turbulence, i.e. an amount of induced drag. In level flight gravity is compensated by lift, therefore an increase in aircraft weight leads to an increase in the induced drag.



For level flight at a constant speed, it is necessary that drag should be balanced by thrust. Drag is proportional to the square of the airspeed and, hence, drag increases geometrically with increase in airspeed requiring ever greater thrust levels. The figure on the next page shows a plot of drag in level flight (a), and of thrust in military power mode (b) versus airspeed at a constant altitude.



In the area where the drag curve passes below the thrust curve (this area lies to the left of Point 1), there is excess of thrust, and the aircraft will climb at a particular speed and AOA (see pictures of the aircraft at the top of the figure). If you prevent the aircraft from climbing by reducing the AOA, it will speed up.

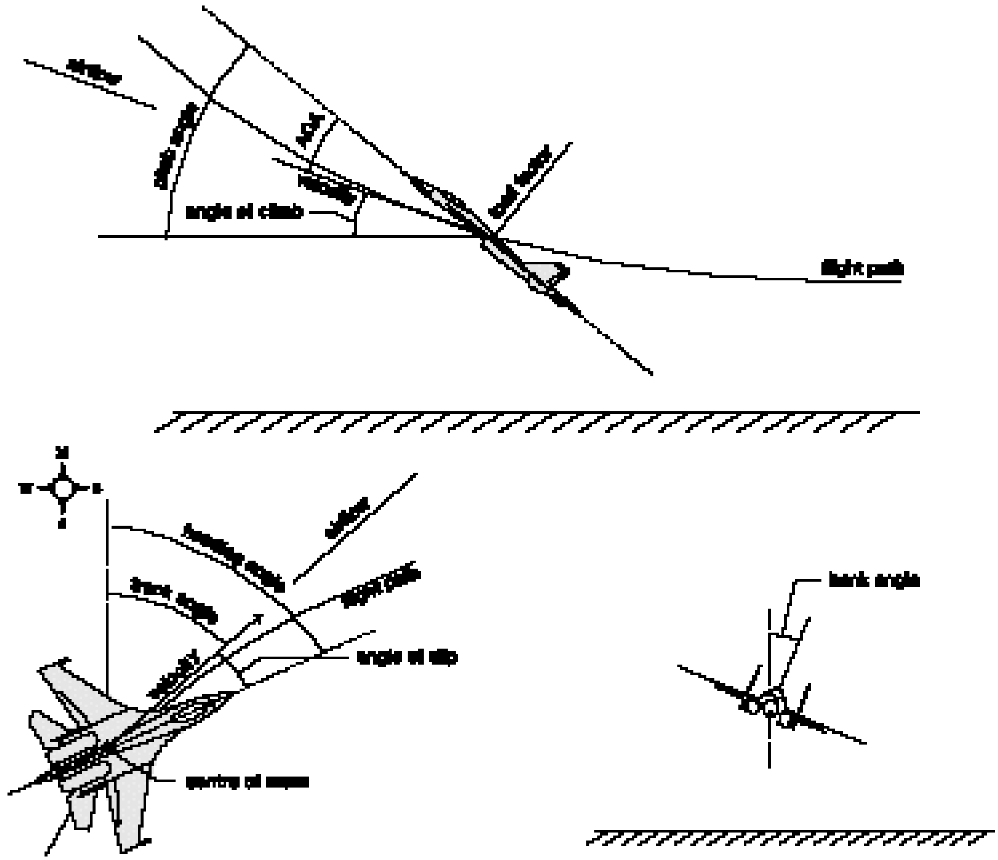
In the event of a deficiency of thrust (area to the right of Point 1), the aircraft will either dive at a constant AOA and airspeed, or decelerate in level flight.

Point 1 on the diagram corresponds to conditions of level flight and characterises the maximum airspeed at military power, while Point 3 corresponds to the minimum airspeed of level flight. The fuel consumption per unit of thrust is a constant value (for the Su-27, it is 0.75 kg of fuel per 1 kg of thrust per hour at military thrust) therefore, the minimum drag (Point 2 in the diagram) corresponds to the minimum hourly fuel consumption and to the maximum endurance on the remaining fuel.

As altitude increases, the drop in air density leads to a decrease in drag and hence to an increase of true airspeed required to maintain level flight at a constant AOA. Note, that indicated airspeed in this situation remains constant.

Principal angles

The aircraft's motion in space can be determined by a set of angles. The figure below shows designations for the most common angles used when describing longitudinal and lateral motion of the aircraft.

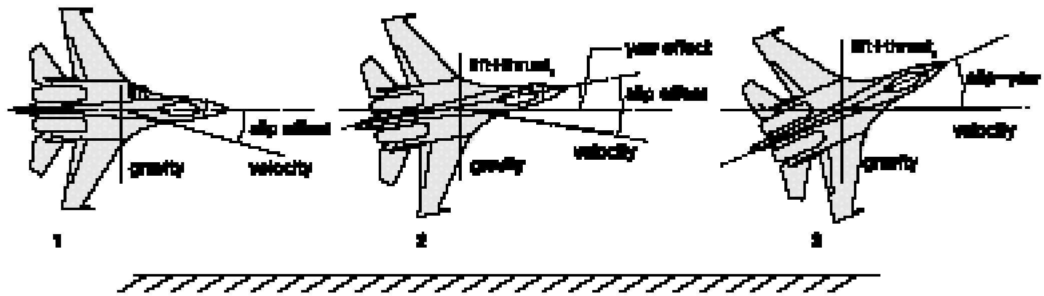


To describe these various angles, it is more convenient to use the vector of velocity rather than air flow. The *velocity* of the aircraft is always opposite to the direction of the air flow and equal to it in the absolute value. The *flight path* is a trajectory of motion of the aircraft's centre of mass, that is the point where all the forces acting upon the aircraft are applied. As you can see the direction of motion at any particular moment doesn't always coincide with the aircraft's longitudinal axis.

The *angle of attack* (AOA) is the angle between the aircraft's longitudinal axis and the direction of its motion, i.e. the velocity vector. Up to a certain degree, the greater the AOA, the greater the lift and drag, and hence the increase in thrust required to maintain a constant speed. If the aircraft flies at a high AOA, the airflow cannot conform to the upper surface of the wing and forms turbulent vortices. The wing starts to lose its performance, and maybe this can result in a dangerous stall or spin and, probably, in a catastrophe.

The *pitch angle* is measured between the horizon and the aircraft's longitudinal axis. Note that pitch angle is not the same as the *angle of climb* which indicates the angle between the air flow (or velocity vector) and the horizon. This angle is also called flight path angle, which when added together with the AOA constitute the pitch angle. Therefore, in level flight the angle of climb is equal to zero.

Besides AOA, another angle describing aircraft motion is the *slip angle*. This angle characterises the asymmetry of airflow passing over the aircraft. This angle may sometimes coincide with the *yaw angle*. The difference between these two angles is illustrated in the figure below.



Slip and yaw effects

All three aircraft are flying in the vertical plane in knife edge. Aircraft 1 is sideslipping towards the ground since the gravity force is greater than lift. The pilot in Aircraft 2 applied some left rudder so that the vertical component of thrust is added to lift and the aircraft develops yaw. Here the aircraft is still going towards the ground but slower. The pilot of Aircraft 3 deflected the rudders further so that the aircraft is moving straight and level (the gravity is fully compensated by thrust and lift). In the third case the slip effect coincides with the yaw effect.

Takeoff

Takeoff does not usually present too many difficulties even to beginners. In due course, this procedure will become second nature and will not require much attention.

Now you are sitting in the cockpit ready for takeoff. Here we go!

1. Extend the flaps into the takeoff position (press **F**) Note that lowering the flaps isn't necessary if your payload is light. Engage the wheel brakes (press and hold down the **W** key).

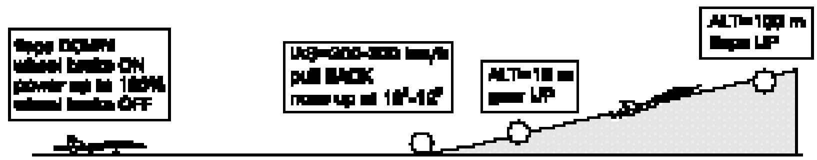
2. Throttle up to military power (100%) by pushing the throttle lever forward to the '**МАКС**' position or by pressing **PgUp** twice. Note that Russian pilots do not engage afterburners on take-off in order to save fuel (unless the aircraft is heavily loaded or the runway is short).

3. On reaching 100% (check RPM Indicator) release the wheel brakes (release the **W** key).

4. When the aircraft accelerates to a speed of 200-300 km/h (check the number in the upper left-hand corner of the Head-Up Display) depending on the load, begin the takeoff by smoothly pulling back on the stick (or by pressing the **DownArrow** key). The nose will rise smoothly. Check attitude at 10-12° nose up (the pitch angle indicator is to the right of the HUD centre). Let the aircraft accelerate in this attitude.

5. When the wheels have lifted off the runway and the rate of climb is positive, select GEAR UP

(press **G**), and at an altitude of about 100 meters - FLAPS UP (press **F**). Check the gear and flaps up on the Configuration Display.



To get a good idea of how to do it right turn to the training mission "Takeoff".

After an initial climb, you usually level off by easing forward on the stick and continue to accelerate until the aircraft reaches cruising speed. On reaching a safe altitude (2000 m) and a comfortable cruise speed (750 km/h) you're set to practice some gentle manoeuvres.

Navigation

A short distance flight from one waypoint to another presents no particular problems. However, navigation becomes much more difficult during bad weather and at night or when you have to follow a tough low level flight path.

The navigation system in the Su-27 can function in one of the following operating modes. The Russian designation of the current navigation mode is shown on the HUD Mode Indicator, which is located in the lower left-hand corner of the HUD. The table below lists all navigation modes available in the aircraft.

Designation	Pronounced	Mode	Purpose
НАВ	'nav'	Piloting	Visual navigation, compass+stopwatch
МАРШ	'marsh'	On-route	On-route navigation
ВОЗВ	'vozv'	Return	Return to the initial approach beacon prior to landing
ПОС	'pos'	Landing	Activates the Instrument Landing System (ILS) and autoland facility

To switch the Flight Control System to a particular navigation mode, enable the Navigation Mode (press the **1** key) and then cycle through the above-mentioned submodes by pressing **CapsLock** until you select the desired one.

Automatic Control System

In the **МАРШ**, **ВОЗВ**, and **ПОС** modes you can either fly manually on instruments or automatically. In the latter case the Automatic Control System (ACS) computes the required values of the flight parameters in accordance with the flight plan and generates the control inputs. The ACS has two operating modes:

- Autopilot
- Altitude Stabilisation (H-stab).

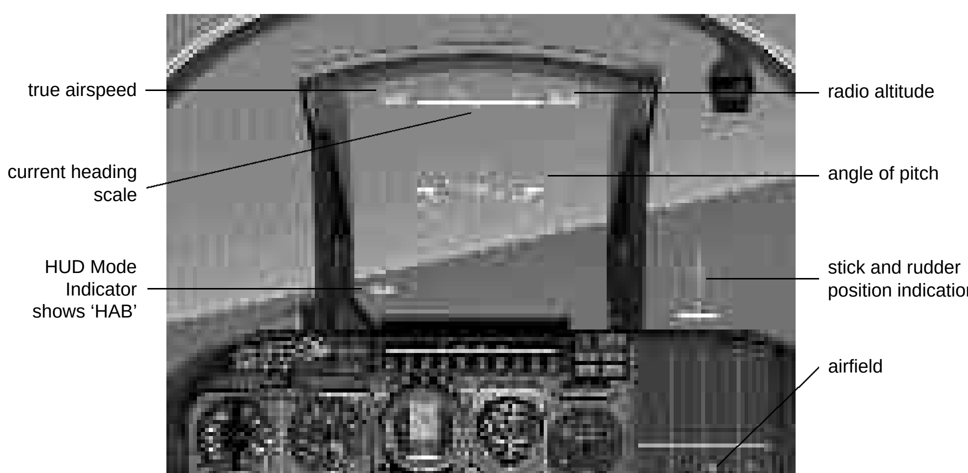
In these modes, the ACS produces the required angles of pitch, roll, and yaw. These values are displayed on the HUD and flight instruments (the ADI and HSI) along with the guidance reticle. However the Su-27 does not offer autothrottle. Target airspeeds are indicated on the HUD in small above your actual airspeed (TAS indicator). You must manage thrust and aircraft configuration such as flaperons, gear and so on. To toggle the autopilot, press the **A** key. If autopilot mode is engaged, the Autopilot Engaged Indicator '**ABTO**' (AUTO) on the instrument panel will be highlighted.

You can use *Altitude Stabilisation* mode both for navigation and combat. In this mode, the ACS provides stabilisation at a particular barometric altitude. The Altitude Stabilisation mode is useful for accurate air-to-ground weapons delivery, especially for bombing. To toggle Altitude Stabilisation mode, press the **H** key, the '**H-стаб**' indicator on the instrument panel will light up.

Note that both ACS modes are mutually exclusive. This means that to enable altitude stabilisation mode, you should disable the autopilot and vice versa. The maximum bank angle handled by the ACS is 60°. The value of pitch control input does not exceed 50% of the maximum pitch input available from the stick when flying without the aid of the ACS.

Piloting mode

The '**HAB**' piloting submode is automatically enabled when you switch to Navigation Mode by pressing the **1** key. This mode can be used when you don't need to follow a specific flight plan or fight. In piloting mode, the information shown on the HUD and MFD is minimal. The HUD Mode Indicator shows the '**HAB**' designation of the piloting mode. The HUD displays the main flight information (current altitude, true airspeed, heading, pitch, roll). The Multi-Function Display (MFD) shows airfields and illumination sources if such are detected by the Radar Warning System (RWS).



Trimming

Depending on your airspeed, maintaining straight and level flight often requires a little angle of attack, achieved by pulling back on the stick slightly. To maintain level flight in this manner for a long time is very tiring, as you would be forced to constantly hold the stick in the same position. The trim controls make your piloting easier by feeding some control signal to the aerodynamic controls when the stick is in the neutral position. Applying trim with the help of the trim controls, relieves you of having "to hang on" to the stick: you can release the stick and still fly level.

If you use the Thrustmaster F-16 FLCS joystick then you can extend the trim tabs by moving a special trim button to the required side. To trim from the keyboard, you can use the following keys: **Ctrl+Comma** (trim left), **Ctrl+/** (trim right), **Ctrl+Period** (trim up), **Ctrl+Semicolon** (trim down). In so doing, if the indication of the stick and rudder position is enabled (press **Ctrl+J** to toggle) you can see the circle representing the stick move in the corresponding direction. Apply as much trim as is needed. When trimming is no longer required, disable it by pressing **Ctrl+T**, this sets the trim tab to the neutral position (check the stick position indication).

If needed, you can also trim the rudders. This is mostly useful when flying with one engine out (see Chapter 7, "Warnings and Failures"). To apply trimming, use **Ctrl+Z** for the left rudder and **Ctrl+X** for the right rudder.

On-route mode

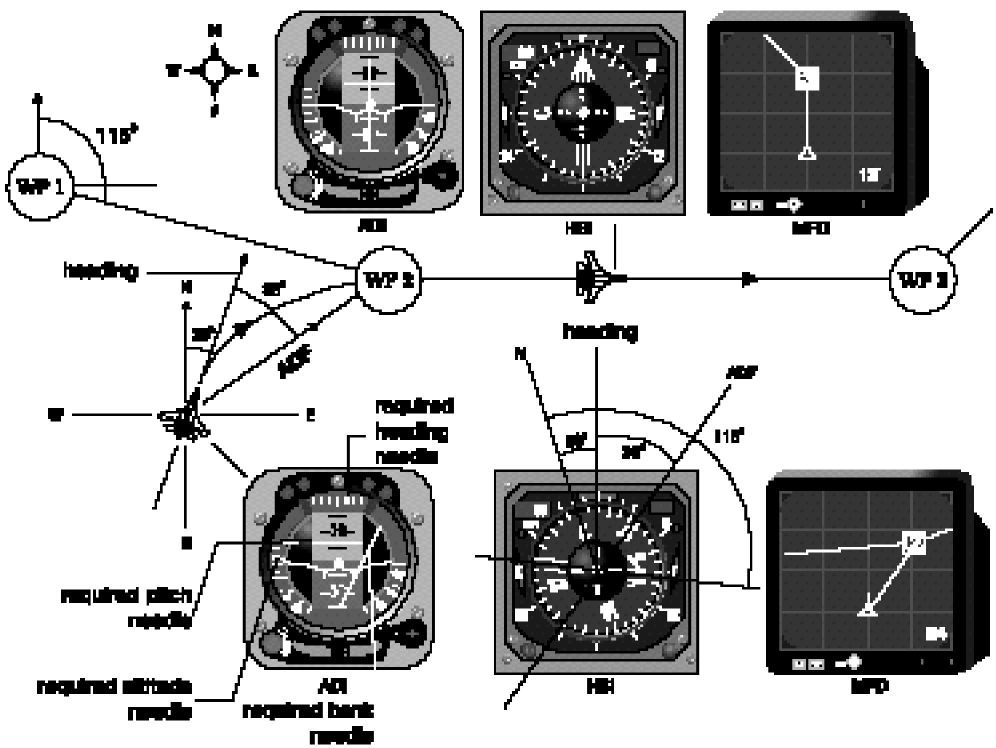
A flight plan usually consists of several waypoints. If the autopilot is not engaged, the pilot approaches the waypoints manually, by using the flight information displayed on the HUD and on the flight instruments. If you completely entrust this task to the autopilot, it will monitor most of the parameters of motion and will select the next waypoint of the route very shortly prior to the arrival at the current one.

The On-route mode ('**МАРШ**') aids the pilot in following his planned flight path by supplying the pilot with route information. Each waypoint is characterised by its coordinates on the ground, the altitude above the ground, and leg airspeed. When you switch to On-route mode, the HUD Mode Indicator shows '**МАРШ**'. The HUD displays the Flight Path Marker as a small circle, the distance in kilometres to the current waypoint (a number at the bottom), the required altitude (a small number above the current altitude indicator), and the planned speed for the leg (a small number above the current speed indicator). The MFD shows your waypoints as circles connected by a polygonal line. The current waypoint is always enclosed in a square. You can select a particular waypoint at any time by cycling through the waypoints with the **Tilde (~)** key.

After you have reached the current waypoint, the navigation system automatically switches to the following waypoint. When the aircraft has reached the last waypoint of a route, the navigation system automatically switches to Return mode ('**ВОЗВ**').

To approach a particular waypoint manually, you should keep the Flight Path Marker in the centre of the HUD marked by cross hairs, and maintain the required airspeed by throttling accordingly.

The HSI displays the distance to the current waypoint, your current heading (the rotating scale), the current waypoint bearing (the narrow arrow) and the bearing from the previous to the current waypoint (the wide arrow).



Instruments indication in On-route mode

In the figure above the aircraft on approach to Waypoint 2 is misaligned by about 35° left. This is reflected on the HSI (see the instruments at the bottom of the figure): the current heading is 20°, and the Automatic Direction Finder (the narrow arrow) reads 55°. The distance to the current waypoint is shown in the upper left-hand corner of the HSI and here equals 30 km. The selected radial, i.e., the bearing from Waypoint 1 to Waypoint 2 is shown by the designated flight path needle (the wide arrow) and is equal to 115°. Note that this needle is parallel to the line connecting Waypoint 1 with Waypoint 2 (surrounded by a circle) on the MFD.

The ADI also shows a misalignment between the bearing to the current waypoint and the aircraft's current heading. This is indicated by the deflection of the required heading needle and the required bank needle to the right. The required altitude needle to the left indicates that no pitch input is required to reach Waypoint 2 at the planned altitude. The pilot should fly the aircraft so that the required bank needle approaches the centre of the ADI and remains upright.

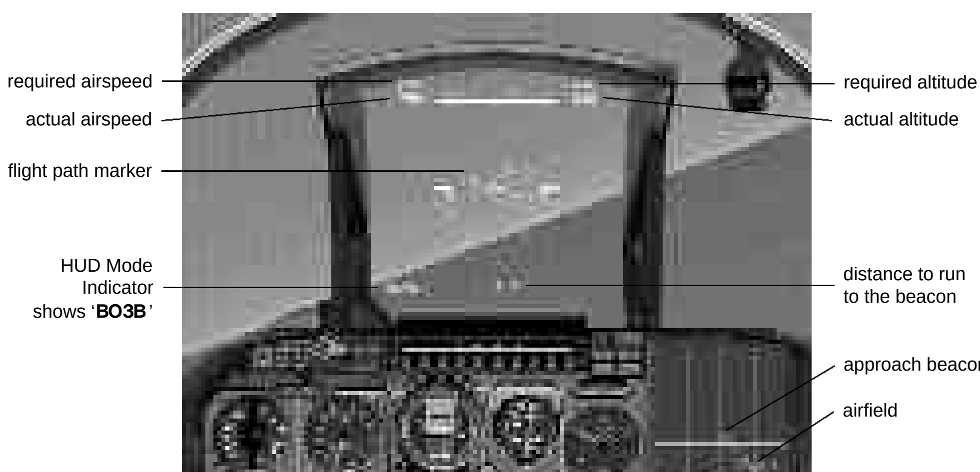
If the aircraft is on the planned flight path, as is the aircraft above between Waypoints 2 and 3, then the wide and narrow arrows on the HSI are aligned. Furthermore, both the arrows on the ADI remain upright.

To stay on track in the presence of wind, it is necessary to align the required heading needle on the ADI not with the fixed heading index, but with the angle of drift needle.

Return mode

The purpose of Return mode ('**BO3B**') is to position the aircraft for approach to land on a selected airfield (see the figure below). Such a point is called the initial approach beacon. It is a characteristic point for any runway and provides convenient conditions for an approach to the runway. If the airfield you are going to land on is equipped with an Automatic Landing System (ALS), flying to the initial approach beacon also ensures that you'll get within the narrow radio beam of the ALS. Note that you cannot assign the approach beacon on your own when designing your flight plan.

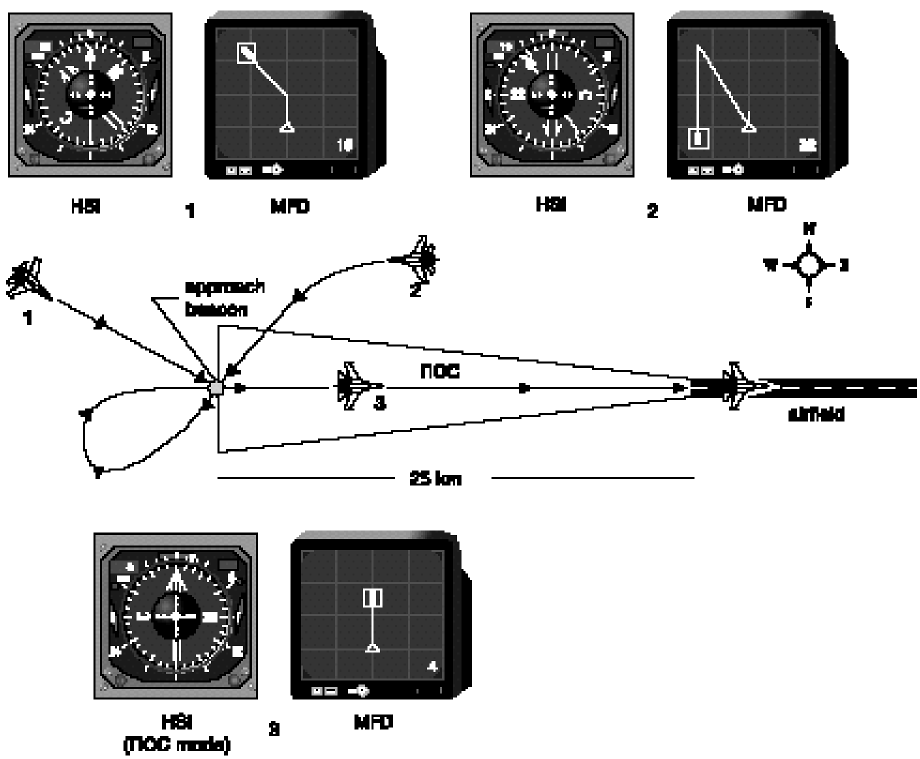
A return to an airfield begins automatically when you have reached the last waypoint of your route. If required, you can also manually switch the navigation system to Return mode at any time by pressing **CapsLock**. When the Return mode is activated, the HUD Mode Indicator displays '**BO3B**' (RETURN). Information displayed on the HUD and MFD is similar to that in the On-route mode. The approach beacon is not specially marked on the MFD. It is presented by a point



connected with the airfield and with the symbol of your aircraft by two lines (see the figure below). You can cycle through available airfields along with their approach beacons by pressing the **Tilde (~)** key.

Piloting the aircraft in the Return mode is similar to en-route piloting. To approach the beacon in manual mode, hold the flight path marker in the HUD centre datum and maintain the required airspeed.

When flying towards the approach beacon, the wide arrow on the HSI always indicates the bearing from the beacon to the selected airfield and normally is the same as runway heading. The figure below illustrates the readings of the HSI and the MFD for three aircraft each with different positions relative to the approach beacon. Aircraft 1 is at a distance of 10 km from the beacon and is flying on a heading of 135° on track to the radio beacon. Aircraft 2 is flying on a heading of 270°, and its distance from the beacon is 10 km. The bearing to the beacon for this aircraft is 235° (see the ADF). The misalignment between the current heading and the required heading is 35°, in other words, the pilot must turn 35° left to be on track to the beacon. Aircraft 3 is flying away from the beacon and is in the direction of the runway heading.



HSI and MFD indications in Return mode

When the aircraft has reached the beacon, the navigation system automatically switches to Landing mode ('**ПОС**').

Landing

Remember, the secret to all good landings is in the approach!

Landing is often considered the most difficult and critical part of flying. In the Flanker if the selected airfield is equipped with the Automatic Landing System (ALS), you can turn on the autopilot, which will take care of most of the landing operations. Once again, you should only control thrust and aircraft configuration (flaps, landing gear, air brake, drogue chute). However, autoland mode is not always possible; the airfield may not be equipped with ALS or your onboard navigation equipment may be damaged. Here you will have to rely on skill alone.

Automatic landing

To land the aircraft in automatic mode, engage the Autopilot (the **A** key) and switch to Return mode. The autopilot will fly the aircraft to the approach beacon. On arrival at the beacon the navigation system will switch to the Landing mode ('**ПОС**'). Then the autopilot will bring your aircraft down the ILS glide path right to the runway threshold, using signals from the airfield's ALS. As soon as you fly over the runway threshold the autopilot will change to bank stabilisation mode in which it stabilises zero bank angle and damps the vertical speed. The autopilot disengages on the touchdown, or in 15 seconds after the bank stabilisation mode is enabled, or when the aircraft loses the ALS beam.

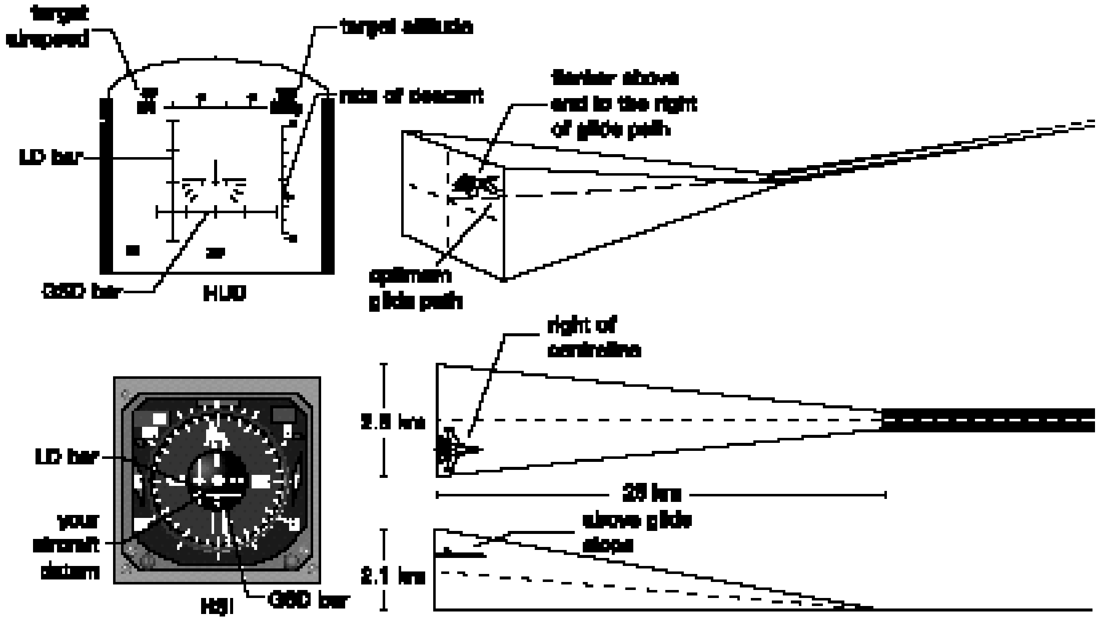
Have very tight control of your airspeed! Don't forget to select timely deployment of the aircraft's mechanics (gear, flaps, air brake), and brake to a full stop. When close to the threshold you can take over manual control.

Semiautomatic landing

After you have reached the approach beacon the navigation system automatically switches to Landing mode which is evidenced by the change of information on the HUD: the '**ВОЗВ**' designation on the HUD Mode Indicator is replaced by '**ПОС**' (LANDING) and the aircraft's Instrument Landing System (ILS) is activated. Once in Landing mode you cannot select another airfield without switching back to Return mode.

Instrument Landing System

Many airfields are equipped with the Instrument Landing System. The ILS generates the optimum approach trajectory (the *glide path*) with the help of two mutually perpendicular fan-shaped radio beams: Glideslope (horizontal) and Localiser (vertical). The range of the system is equal to about 25-30 km (see the figure on following page).



The aircraft above is flying within the limits of the glide path cone slightly to the right and above its centre at a distance of about 23 km from the airfield (see the number in the upper left-hand corner of the instrument). As the aircraft is flying in parallel to the runway, the designated flight path needle (wide arrow) is aligned with the fixed heading index, that is, it coincides with the runway heading, which is 90°. However, as the flight trajectory differs from the optimum, the ADF (narrow arrow) indicating the direction to the airfield radio beacon is not perfectly aligned with the designated flight path needle but it is deflected to the left by a few degrees and shows a heading of 87°.

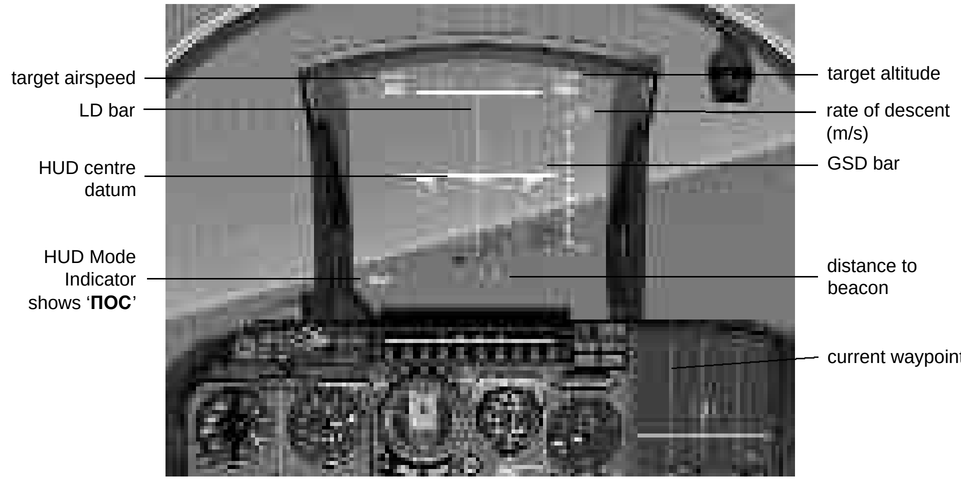
The two intersecting bars in the centre of the HSI are the vertical Localiser Deviation (LD) Bar and the horizontal Glide Slope Deviation (GSD) Bar. They indicate your deviation from the runway centreline and the glide slope, respectively. Here, turn left five degrees until the LD Bar is centred and the wide and narrow arrows on the HSI are parallel. Then turn right back onto 090°. Further more let the aircraft descend a little until you're comfortably on the glide slope.

Get on the glide slope early on and hold the aircraft on the glide path. Use the ADI to assist your approach. It shows information on bank and pitch angles and mismatching heading and altitude. When landing, you should keep the required bank needle upright and the required pitch indicator at about the zero position.

Note: As the ADI gives required data to the pilot, it gives more information than the ILS — the ADI will tell you "where to go and how" to reach the optimum glide path. The ILS just tells you "where you are" in relation to the optimum glide path.

Hold the glide path, keep the intersection of the two ILS bars in the centre of the HUD. Manoeuvre the aircraft gently and control your airspeed to match the required airspeed displayed.

The HUD indicates the distance to run to the beacon. Note that the beacon is not situated at the runway threshold but at about 300 metres in. This is to ensure that the pilot won't land short. The vertical scale to the right indicates your rate of descent (or climb). The MFD shows a symbol of your aircraft connected with the airfield by a line. The airfield chosen for landing is enclosed in the square lock frame.

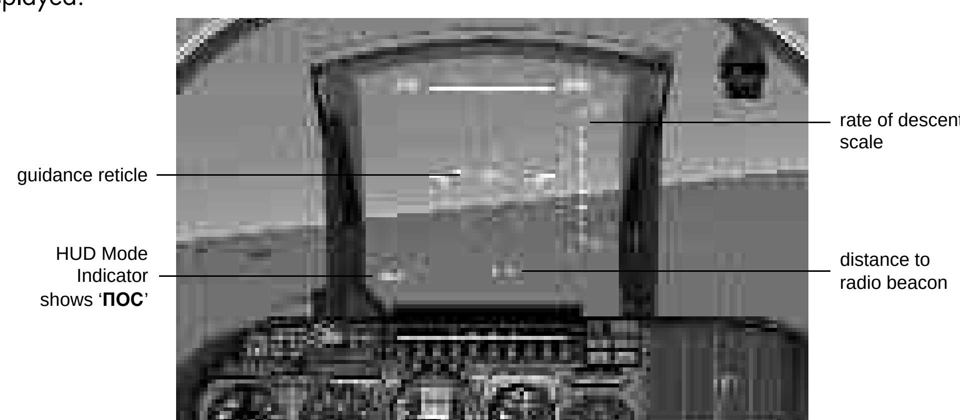


HUD symbology in Landing mode with the ALS

You should control airspeed and aircraft configuration as described in the section below.

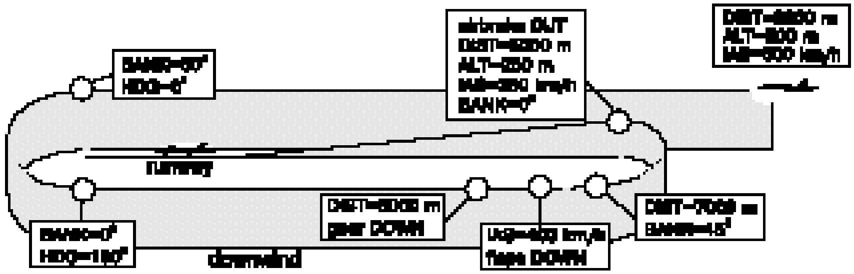
Landing without the aid of ILS

If an airfield does not have ILS or the aircraft is beyond the operating range of this system, you should guide the aircraft to the airfield using information on bearing to the radio beacon, distance to run and runway heading. In this mode the HUD displays the guidance reticle showing the deviation of your current heading from the required one, which coincides with the bearing to the radio beacon (see the figure below). Besides, the rate of descent scale to the right helps you control your vertical speed. At the bottom of the HUD the distance to the airfield radio beacon is displayed.



HUD symbology in Landing mode without the ILS

A visual approach and landing should usually be made according to the following procedure (see the figure below).



Initial approach

5-10 km to runway

Keep your airspeed at 500-600 km/h and altitude at 500-600 m. Line up with the runway (check the HSI and MFD).

Over runway

Maintain an altitude of 300 meters and an airspeed at 450-500 km/h. At runway centre break left (or right depending on circuit direction) at a bank angle of 60° to 80° to join a downwind leg (parallel to runway).

5 km from threshold on downwind

Deploy the landing gear (the **G** key) and air brake (the **B** key). Slow down to 400 km/h, then extend the flaps (the **F** key).

7 km from threshold on downwind

Make a left turn back at a bank angle of 45° to base leg (perpendicular to runway). As and when required turn finals, line up with runway heading.

Final approach, visual

First remember a little trick from one pilot to another:

Move the stick
as LITTLE and as SMOOTHLY
as possible!!!

Maintain airspeed at 400 km/h. Descend at a rate of 4 m/s.

5 km to runway

Reduce airspeed to 350 km/h, altitude 250-300 meters.

Runway threshold

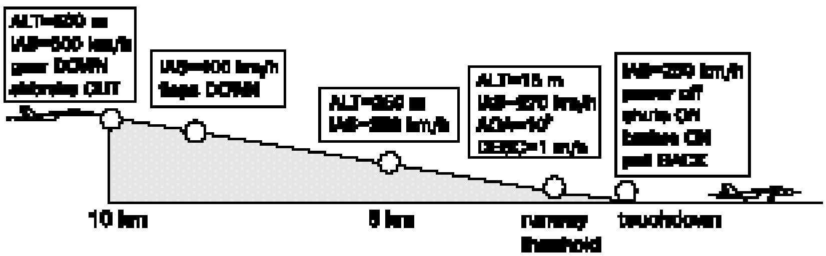
Ideally, over the runway threshold your airspeed should be at 270-290 km/h, and altitude at 10-15 m. However, you can successfully land even from an altitude of 50 meters and at airspeed of 250 km/h. Smoothly flare the aircraft (use the rudder pedals, if necessary) and keep an AOA of approximately10° and a rate of descent of 1-1.5 m/s. In any case, your vertical speed must not exceed 3.8 m/sec or you risk damaging the landing gear. If you feel the aircraft is sinking fast, throttle up immediately.

Touchdown

The aircraft should have a speed of 220-250 km/h. Deploy the drogue chute (the **P** key) and cut the engines to the ground idle. Apply the wheel brakes (press and hold down the **W** key) and pull back on the stick — this will force the aircraft against the runway and assists in decelerating it since the tailerons deflected up start to work as an additional air brake. Slow down to a stop or to a speed of 10-30 km/h, if further taxiing is required.

Taxiing

If necessary, release the stick and wheel brakes, and taxi along the runway using the rudder pedals. Retract the air brake and flaps. Relax!



For landing training turn to training missions.

Landing in a crosswind

In a crosswind, the task becomes a little more difficult since it is necessary to consider the drift of the aircraft with respect to the runway heading. To land properly, it is required that the aircraft's velocity with respect to the ground should be parallel to the runway heading. This can be achieved in two ways.

To maintain translational movement in the direction of the ground speed vector (GS), the pilot should bank a little to the windward wing side while flying towards the runway and flare with a slight deflection of the stick in the direction of the wind. An increase in crosswind speed as well as decrease in the aircraft's true airspeed results in an increase in the slip angle required to compensate for drift. Intense crosswind may lead to maximum deflection of rudders and flaps, which could make landing impossible.

In the second case, the aircraft develops a heading lead angle and moves without sideslip with respect to the runway. Hence, there is no need to control the position of the rudder and flaps while closing in to the runway. Right before the touchdown or on the touchdown, line up the aircraft with the runway. As opposed to the first method, this method makes it possible to land at higher crosswind speeds, yet is more complicated in the piloting technique.

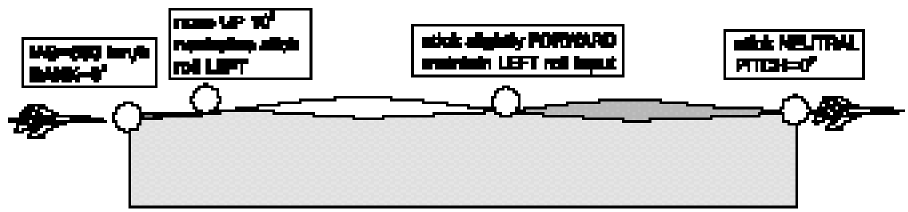
Manoeuvring

Command of the Flanker's full flight envelope is vital in combat. You should know all the capabilities of your aircraft in order to succeed in a fight. Get to the stage where you don't need to think what your aircraft can or cannot do but entirely concentrate on your enemies and the mission. As such, basic aerobatics is the best way to begin.

Aerobatics are basically just a combination of rolls, loops, and turns, so let's get those hacked first. For a full demo on aerobatics go to training missions (see also Chapter 13 'Special Features')

Roll

While executing a *roll*, the aircraft is turning about its longitudinal axis by 360° keeping the general direction of flight.

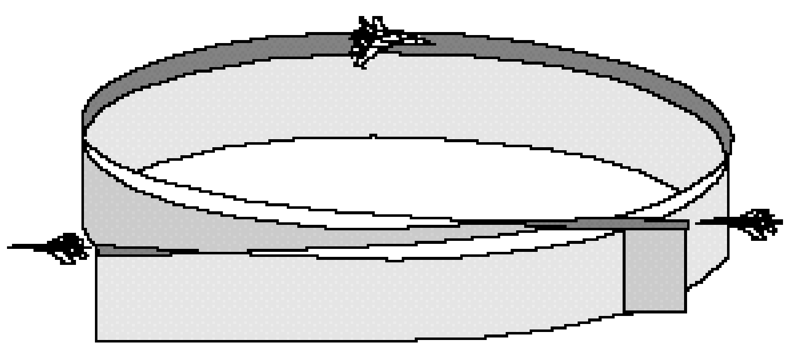


1. Airspeed from 400 to 800 km/h. Smoothly pull the stick back to 10-15° nose up pitch angle. Fix the aircraft in this attitude briefly by very slightly pushing forward on the stick beyond the neutral position.

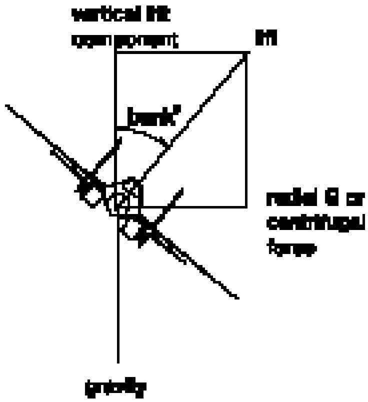
2. Deflect the stick to the desired direction of rotation keeping a rate of rotation at 60-70°/sec.

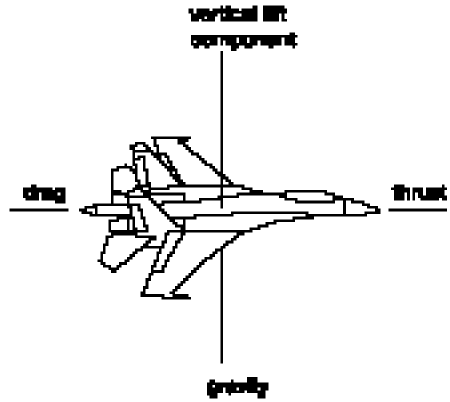
3. Recover wings level and pitch angle of -2° to 0°.

Banked turn



To execute this simple manoeuvre precisely can prove to be trickier than it looks. The diagram below shows the forces acting on the aircraft during execution of a banked turn. To execute this horizontal manoeuvre it is necessary for the aircraft's vertical lift component to be equivalent to the force of gravity acting on the aircraft. The values of lift and bank angle determine the value of this component: the greater the bank angle, the less the vertical component of lift, and hence more lift is required to "lengthen" the vector of the vertical lift component. The G-load required to produce extra lift and thereby execute a banked turn is one of the main parameters of the manoeuvre. It increases non-linearly with the increase of bank angle. So the execution of a banked turn with a bank of 45° requires a G-load of +1.4 Gs; with a bank of 60°, +2 Gs; and with a bank of 80°, +5.75 Gs.





The *rate of turn* (RT) is one of the main characteristics of a banked turn and is measured by the number of degrees the aircraft turns per second at constant airspeed. The Su-27 shows maximum sustained RT at sea level of about 22.5°/sec (at an IAS of about 650-700 km/h and G-load of 6 Gs). This is not the same as instantaneous rate of turn which can be sustained for less time due to rapid loss of airspeed. Instantaneous RT can be as high as 28° per second.

In principle, the radius of a banked turn is proportional to the ratio of the square of the true airspeed to G-load. So at the maximum angular rate of a turn, a radius of a banked turn is about 500 m.

To keep a steady speed executing a banked turn, it is necessary that thrust compensates drag. Therefore, pulling Gs during a banked turn requires an increase in thrust to compensate for the increased induced drag.

Technique of piloting

1. For a right-hand turn, deflect the stick to the right, thus banking the aircraft, say, to 45°. Return the stick to the neutral position and start a smooth pull back on the stick to initiate a steady rotation.

2. Track the horizon constantly and maintain a pitch angle of 0°, if possible. Keep the G-load corresponding to the bank. If the nose starts to descend reduce the angle of bank slightly and increase the G-load a little.

3. To recover from the turn in a coordinated manner, move the stick forward and to the left. Track the horizon constantly!

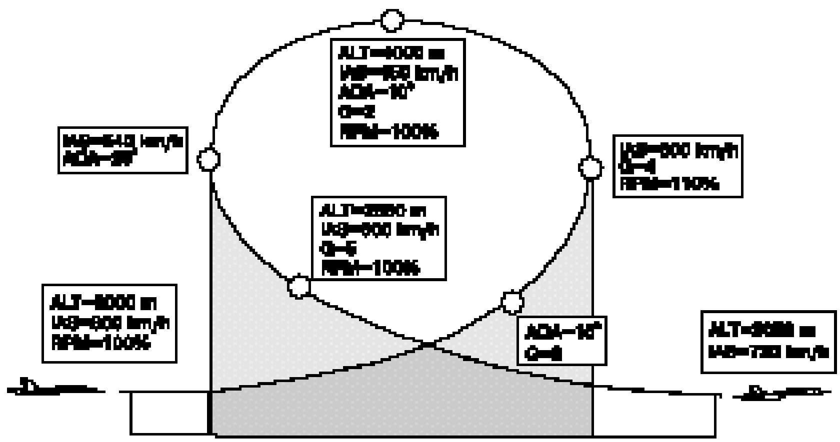
Note that the use of rudder in the Flanker is not really necessary at high speeds. However, should you start flying at speeds below 450 km/h, the use of rudder becomes essential to fly very accurately. For example, initiating a left turn will need a smooth and slight input of left rudder at the initial phase, and rolling out of the turn will require the right rudder. This is nearly impossible to do accurately on the keyboard, however if you possess rudder pedals then feel free to use them and remember a simple rule "slip ball to the left, foot to the left". This means that if the ball of the slip indicator on the ADI goes left, you should push the left pedal forward (the **Z** key).

Loop and half-loop

Before starting a loop make sure your wings are level and the airspeed is 600-900 km/h.

1. Pull smoothly back 5-6 Gs to the moment of reaching a pitch angle of 60°-80°. Engage afterburners.
2. As you go past vertical, gradually reduce G-load, trying to reach at the top of the loop 1.5-2 Gs (at military power) or 2-3.5 Gs in afterburner. Keep the AOA at ~15°.
3. Passing the top point, it is necessary to correct any bank developed on the ascending part of the manoeuvre. Look for the horizon: as it goes past, throttle back to 100% or less and smoothly increase back pressure to 6 Gs.

Typical execution of a loop is illustrated by the following figure:



To perform a half-loop, ascend as described above then execute a half-roll at the uppermost point. This should be done at a sufficient speed, when the nose of the aircraft settles on the horizon. Before executing a half-roll, ease forward on the stick and reduce G-load to 0.5-0.7 Gs.

Reverse turn

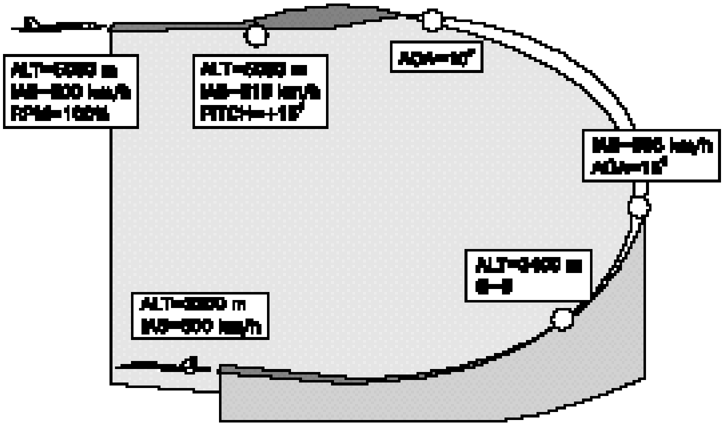
A *reverse turn* is basically a half-roll to inverted followed by a pull through.

1. At speeds from 400 to 900 km/h half-roll to inverted. Check horizon! Don't use too much power!

2. Smoothly pull back on the stick. Maintain as much G as you need. But remember your looking for optimum RT here, so high AOA is not necessarily the best.

3. When recovering from the reverse turn to level flight, smoothly release the stick and return it to the neutral position.

A typical reverse turn is shown in the figure on the following page.



Spiral

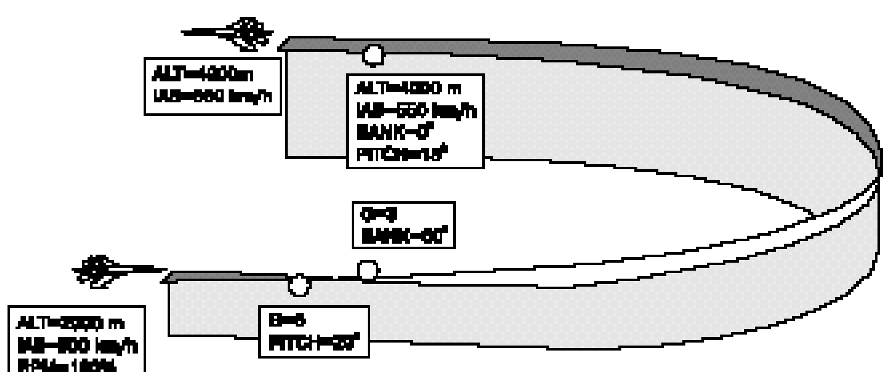
A *spiral* is a manoeuvre, where the aircraft follows a spiral trajectory at relatively high angles of attack ascending or descending. A spiral is basically the same as a tight banked turn going up or down.

Practically, you should execute a descending spiral at a bank of 45-50°. This results in minimal loss of altitude at a turn through a particular angle, including the entry and recovery parts of a spiral. We do not recommend executing a descending spiral at a bank of more than 50° and at pitch angles of more than 20°.

To execute a descending spiral:

1. Slightly pull back on the stick to develop the desired angle of slope. Bank left or right.
2. While keeping the required bank angle, maintain your airspeed by increasing or reducing the G-load. Increase power if necessary. Should the aircraft start to behave oddly (drops the nose, rotates) or there is an increase of G-load, first reduce your bank angle.
3. Once you have reached the desired altitude, recover to level flight.

The figure below illustrates a typical ascending spiral.

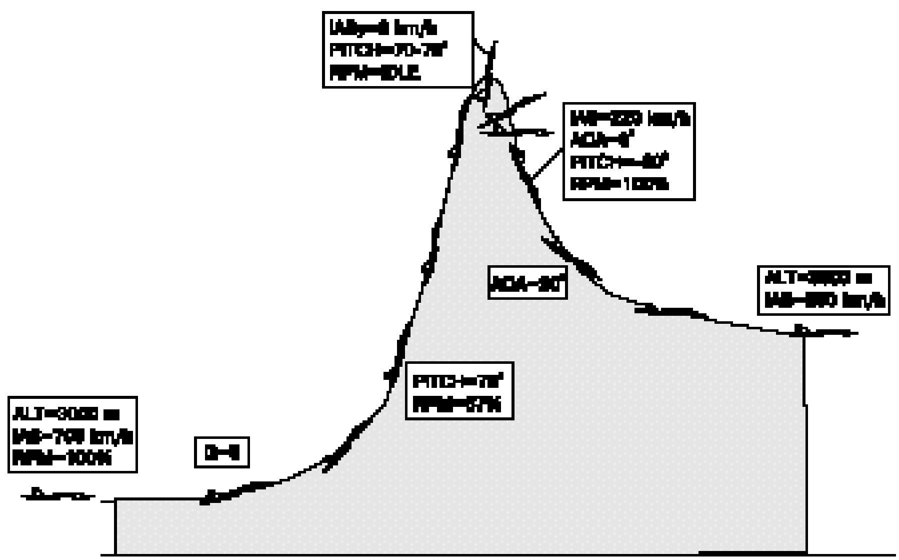


Tail slide

A *tail slide* (also known as the "bell" in Russian) is a zoom manoeuvre executed at a high pitch angle (70-75°). It results in a drop of vertical speed to zero though the horizontal airspeed remains above zero at 10-20 km/h. The aircraft will slide downwards for up to 100 m and then executes a turn in pitch with a recovery to level flight. A typical tail slide may be executed starting at different altitudes and at airspeeds of 500-800 km/h.

This manoeuvre is demonstrated by the Flanker at air shows and is arguably considered of little combat value. However, the experts assert that when an aircraft slows down at the top of the tail slide, it becomes invisible to practically all modern enemy radar systems. Along with the famous Cobra manoeuvre the tail slide dramatically demonstrates the Flanker's staggering capability to remain stable at high angles of attack and low airspeeds and definitely shows superb engine design.

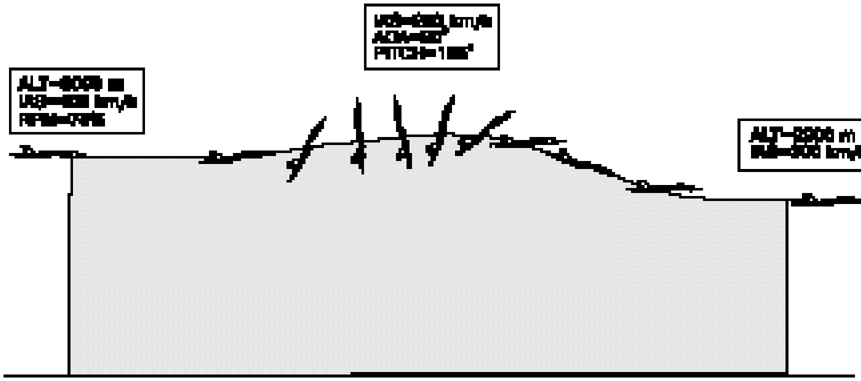
A typical tail slide is shown on the diagram below:



1. Start a climb to the near vertical (70-75° pitch angle).
2. Reduce power to idle and maintain the vertical. Extra care should be exercised while executing a near vertical zoom, as excessive pulling back on the stick may result in an overshoot in pitch beyond the vertical and potential deceleration into high negative AOAs.
3. After the aircraft has begun to fall (develops negative vertical velocity), bring the stick smoothly back. The aircraft will fall forward and nose down. Compensate for any tendency to spin right with the left rudder (the **Z** key). This tendency right is due to the gyroscopic effect generated by the engines. In the real aircraft you would also use some right engine input to compensate for this effect, but unfortunately independent throttles are not available for PC sims.
4. Bring the power up to 100% and let the aircraft accelerate to approximately 500 km/h, then level off normally.

The Cobra

Pugachev's Cobra or *dynamic braking* is a manoeuvre in which within 3-4 seconds the nose of the aircraft is pulled up to high angles of attack (80-100°) and then returned to normal horizontal flight. This causes intensive loss of airspeed. You can execute this manoeuvre from level flight at various altitudes and at indicated airspeeds of 350-450 km/h. The figure below illustrates a typical Cobra manoeuvre:



In real life, to execute a Cobra the pilot should temporarily turn off the AOA and G limiter of the Flight Control System since it restricts the aircraft to the maximum operational AOA of 27.5°. In our program, to execute this manoeuvre, you should first level off at an appropriate airspeed, then press the **K** key, and wait until the aircraft completes the manoeuvre on its own. Since the aircraft's airspeed drops significantly in the process, throttle up in order to prevent stalling as the aircraft goes past vertical.

Stall and Spin

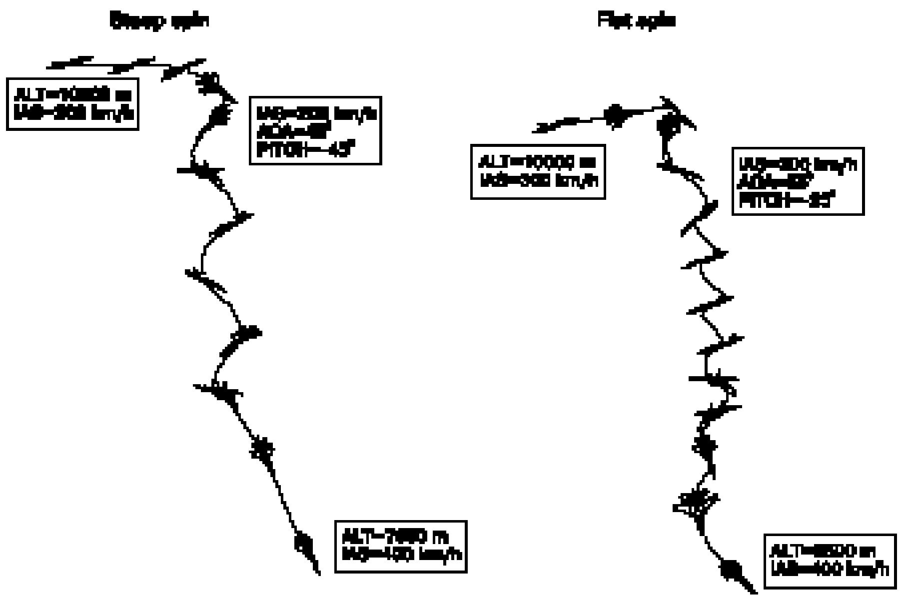
In order to stay airborne, an aircraft must produce enough lift. Flying at low indicated airspeeds and/or high angles of attack may result in the aircraft's inability to generate enough lift, which causes the aircraft to begin spontaneous aperiodic or oscillatory motion with large amplitudes, known as a *stall*. This phenomenon will not cease until the pilot reduces the AOA and may result in a *spin* - a steady-state critical mode of flight at high AOAs. An aircraft in a spin drops at high vertical velocity (50-100 m/s) along a steep and extended spiral of a small radius (from some meters to several tens of meters), while rotating about the centre of mass.

The minimum speed, at which the aircraft is able to fly within its controllable flight envelope, is known as *stall speed*. It directly depends on air density and consequently has different values for different altitudes - the higher the aircraft is flying, the higher the stall speed (if considered as true airspeed).

At high angles of attack the aircraft will start to buffet in pitch, at extreme angles the buffet becomes relatively intense. This is due to air vortices breaking off the wing and disturbing the airflow. This is depicted on screen in amplitude and frequency. Note that at extreme velocities VNE, max flap/airbrake speed, and Cobra, buffeting also occurs but maybe at different frequencies and amplitudes.

A spin can be upright (at positive AOAs) or inverted (at negative AOAs). To distinguish between a normal spin and an inverted one, the pilot can turn to the AOA indicator.

Depending on the aircraft's pitch angle, a spin can be steep or flat. An aircraft in a steep spin rotates with a yaw rate of about 30° per second, while descending at AOA of about 40-45° and at negative pitch angles of -30° to -50°. A flat spin is characterised by high yaw rate (60-80° per second) and high AOA (in excess of 45°). The aircraft's pitch angle in a flat spin does not exceed 30°. Typical steep and flat spins are shown on the figure below.



If the aircraft's AOA is too high, air cannot effectively flow around the wings to produce lift. Flanker's built-in AOA limiter is part of the Flight Control System and limits the aircraft operation to the maximum operational AOA of 27.5°, which is marked by the red Max AOA Index on the AOA Indicator. However, the critical AOA, beyond which the Flanker surely stalls, is 33°. Note that while executing the Cobra, the Flanker's AOA may reach 100° for some seconds, and the aircraft still remains stable due to its unique airframe and superb fly-by-wire FCS. To develop such a high AOA, the pilot disables the AOA limiter by turning it off manually or by applying extra pressure (in excess of 15 kg) to the stick.

One should take into account that increasing AOA to the values higher than 25° leads to a drastic drop in the efficiency of the flaperons — this in particular degrades the aircraft's bank control. At high AOAs and low airspeed we recommend that you bank with the assistance of the rudder. Here banking occurs due to the creation of a sideslip, contributing to the turn. To bank left, you should press the left rudder pedal, to bank right, the right one. However, remember, that:

1. an intensive rotation in the lateral and directional channels produces a destabilising pitch moment, which may cause an increase in AOA beyond the permissible limit;

2. high slip angles developed at an AOA approaching the maximum operational value, may lead to an earlier stall.

3. deflecting the stick in the roll channel at AOAs approaching the maximum operational value, may result in the reverse action (you move the stick left, the aircraft banks right) and furthermore to an earlier stall.

Recovery from stall and spin

Note. To recover from a stall or spin, you should have sufficient height in hand. Indeed, as recovery can take some time, a spin at altitudes of less than 1.5-2.0 km dictates an immediate ejection (the **Ctrl+E** key in our sim). This is the only way, since even if you manage to successfully recover from the spin, you will not have altitude sufficient to recover from the dive.

Once you have noticed that your aircraft responds to control inputs badly and the AOA is above the allowable value, proceed as follows:

1. Place the stick and rudder pedals into the neutral position and wait until the AOA starts to drop.
2. If the aircraft starts to yaw and enters a spin, counter it by deflection of the rudder pedals in the opposite direction. Slightly push the stick forward beyond the neutral position. Throttle back to idle ('**МГ**').
3. If these actions do not help, push the stick further forward. Maintain opposite rudder.
4. If the rotation does not ease within 5-6 seconds, deflect the stick in the direction of spin.
5. As final solution if spin persists, bring the stick all the way back while maintaining in spin aileron. If even this doesn't help and your altitude is less than 1.5 km, eject!
6. As soon as the rotation slows, which may take about 5-10 seconds, release the rudder pedals and the stick to the neutral positions at once. Note that any delay may result in entering a spin of the opposite direction. Maintain forward pressure on the stick to reduce the AOA.
7. After the AOA drops below the maximum operational value, wait until the aircraft accelerates to 350-400 km/h, then power up and level off.

If a stall occurs at negative angles of attack and the aircraft enters an inverted spin, the remedy is basically the same as described above with the exception that you should deflect the stick in pitch channel in the opposite direction.

Note On Good Airmanship

All aircraft of this type are designed to operate under positive G-loads. So avoid the following:

- In a climb, to level off, don't just push on the stick! Execute a half roll, pull until the nose is on the horizon then roll out to straight and level.
- To enter a steep dive don't just push on the stick! Execute a half roll to inverted and pull to the required dive angle, say 45° nose down, then half roll back to erect.

Remember, pushing negative Gs is bad for the aircraft, bad for you and not effective airmanship!

Chapter 4. Weapons

Before describing air-to-air and air-to-ground engagement, we shall dwell briefly on the weapons used by the Flanker and other Russian aircraft, as the knowledge of their principles of operation, main specifications, conditions and methods of delivery are vital for successful combat.

Since the Flanker's primary purpose is interception and air superiority, it was designed to carry up to 10 Air-to-Air missiles (AAMs), located on 10 pylons (on the wingtips, under wings, and under the engine nacelles).

Although designed specifically as an interceptor, the Flanker has been adapted as a ground attack aircraft, though its radar and weapons control system lacks the most recent technologies now available. The special "universal" pylons can carry up to sixteen 250-kg or eight 500-kg blast fragmentation or cluster bombs or six new KMGU cluster bombs. Alternatively, the aircraft can carry up to eighty 80-mm unguided rockets or twenty 130-mm rockets in four pods, or four 250-mm rockets on individual O-25 launchers. Finally, a wide range of guided bombs and air-to-surface missiles (ASMs) are available.

When operated in the ground attack or intercept role the Flanker's wingtip launch rails can be replaced by Sorbtsiya ECM pods.

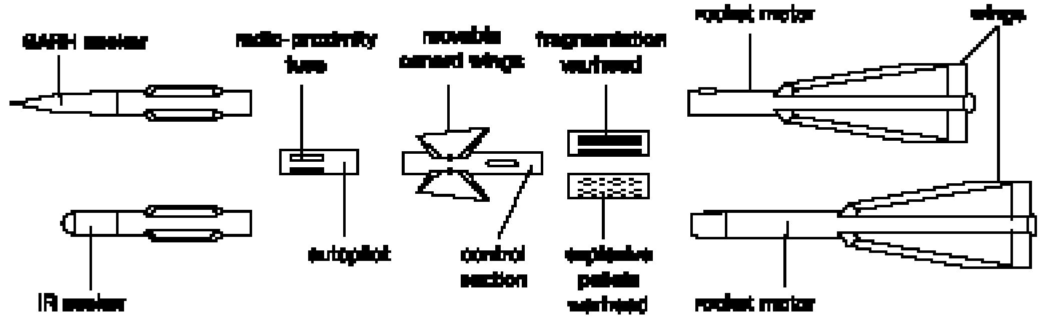
Finally, the aircraft is equipped with the GSh-301 automatic cannon fitted in the starboard wingroot, the same weapon as is used by the MiG-29. Designed by the OKB led by V.P. Gryazev and A.G.Shipunov, the cannon is used in conjunction with the laser rangefinder. The GSh-301 is provided with 150 rounds of ammunition and is capable of firing at 1500 rounds per minute.

Air-to-air Guided Missiles

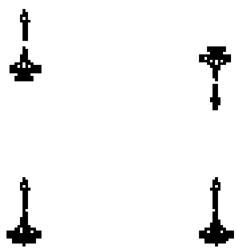
All guided missiles are categorised according to their mission: air-to-air, air-to-surface, surface-to-surface and surface-to-air. This section deals with air-to-air missiles, but much of the material is also relevant to other types, particularly surface-to-air missiles (SAMs), which are discussed later in Chapter 8 "Understanding SAMs and Countermeasures".

Most air-to-air missiles have a solid-propellant rocket or jet engine which provides just a few seconds of thrust. The missile accelerates to its maximum speed just before the fuel burns out and thereafter relies on its inertia for the remainder of its flight.

Typical AAM, R-27 (AA-10 'Alamo') is shown in the figure over the page in two major modifications: with semi-active radar homing (SARH) seeker and with the infrared (IR) one.



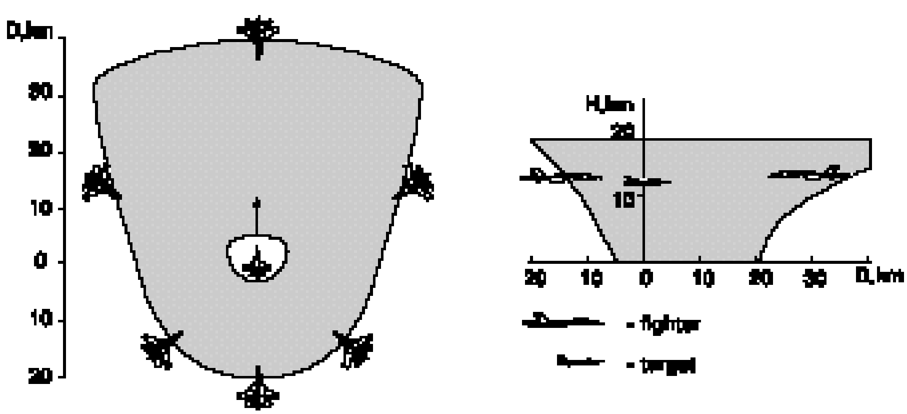
Operational envelope



Let us consider a typical missile launch at an oncoming target and a retreating target moving in a straight line on the same heading as your aircraft. If the target and the missile are moving towards one another, the maximum launch range significantly increases.

If a missile is trying to catch up with a target, the missile range may drastically decrease, as it must catch up with a target "running away" from it. Maximum launch range also depends on altitudes and speeds of the target and the missile carrier. The SR-71, for example, flew so fast and so high that "catching up" with it proved impossible for close on 25 years!

The figure below shows a typical missile envelope (the grey zone) for a non-manoeuvring target. This envelope is a diagram looking down from above a target, which is flying towards the top of the page and located within the centre of the inner (white) zone. The outer and inner boundaries depicted illustrate the missile's capabilities and limitations.

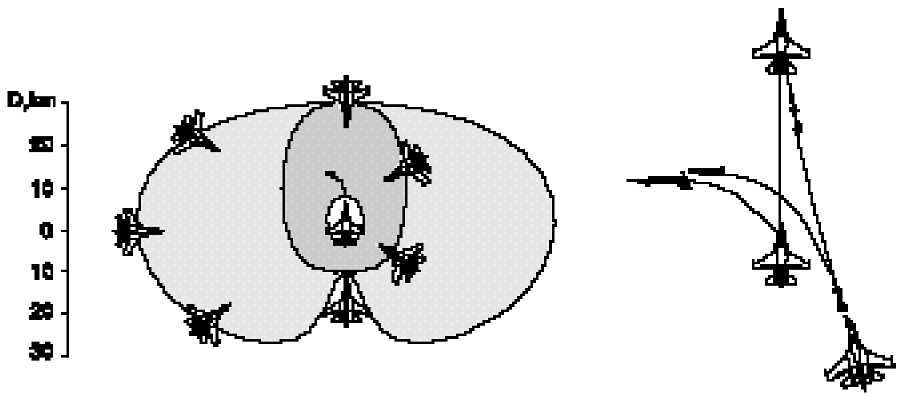


Missile envelope for non-manoeuvring targets

The outer boundary is the maximum range at which the missile is capable of guiding to within the lethal miss-distance of the target. This boundary reflects the capabilities of the missile's propulsion, guidance, and control systems, and the aspect from which the missile is launched. One of the most striking features of this boundary is the great difference in maximum range between forward-quarter and rear-quarter shots.

The inner boundary surrounding the target is the minimum-range limit. Depending on the aspect this may be the result of fuse-arming time, the missile's turning capability, guidance reaction time, or the seeker's gimbal limits.

If you launch a missile at a manoeuvring target, the trajectory of the missile's motion will be essentially curvilinear, which will lead to an increase in drag and, therefore, to a reduction of the maximum launch range. To illustrate the change in the missile's envelope we chose a turn as a typical manoeuvre. The fact that the target may turn in either direction greatly influences the maximum range of launch. That is why the missile operational envelope (the smaller grey area in the picture below) represents the area shared by envelopes for left-hand and right-hand turns of the target (the larger grey areas).



Missile envelope for turning targets

In addition to the restrictions imposed by their operating envelopes, AAMs also usually have aiming requirements. Since guided missiles can correct for some aiming error, the aiming restrictions for them are much looser than those for unguided weapons, but there are restrictions nevertheless. Some missiles must be launched along the Line Of Sight (LOS) in order to detect and guide on the target. Others may be launched with lead or lag. AOA is also a factor since missiles usually weathercock toward the relative air-flow immediately after launch.

Guidance

The missile's guidance systems provide inputs to the missile's control system, which in turn manoeuvres the missile to intercept the target. Most modern AAMs are based on homing guidance. When homing, the guidance law is formed in the missile's computer using information on target motion. There are three types of homing: passive, semi-active, and active.

The simplest of these types, passive homing relies on emissions given off by the target itself (radio, heat, light, sound). In the case of active and semi-active homing, the target is illuminated (usually by radar or laser), and the homing system guides on the illumination energy reflected off the target. For active homing guidance the missile itself illuminates and tracks the target. Semi-active homing implies that some source external to the missile (for example, the radar of the launching platform) illuminates the target.

Some missiles, especially long range ones, use combined guidance: inertial radio-corrected guidance and homing on the terminal part of flight. To implement inertial guidance, the launching aircraft computer feeds into the missile's control system information on target coordinates, trajectory and relative speed.

After the missile has started, its guidance system uses the information about the relative position of the missile and the interception point computed by the navigation system. During the flight of the missile, the interception point may significantly change. For this reason, radio correction supplements the inertial guidance, this increases the accuracy with which the missile reaches the target area. Upon approaching the target, the guidance system switches to homing, passive, active or both.

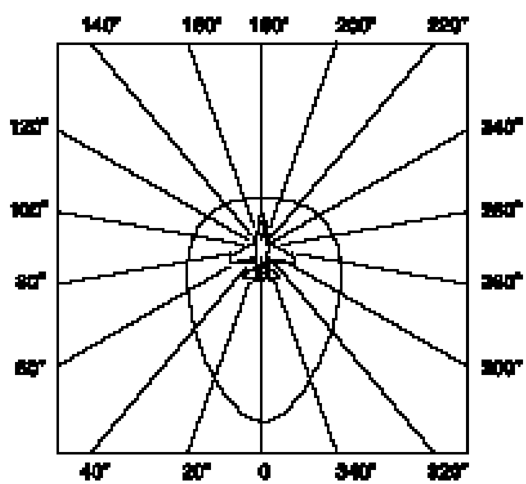
To home, a missile needs a device that will receive radiation from a target (sense it) and track the target, this device, known as a seeker, is located in the nose of the missile. However, semi-active homers may include a rear receiver for reception of information from the illuminating platform. Active homers contain a transmitter and receiver generally located forward. Depending on the type of radiation received by the missile, the seeker may be of infrared or radar type.

Passive homing

Most seekers with passive homing are infrared (IR) seekers reacting to heat-radiating objects. This device contains a material sensitive to heat (IR radiation) that is produced primarily by the target's propulsion system. The detector is often cryogenically cooled to eliminate internally generated temperature and allow detection of even very small amounts of IR energy coming from an external source.

The range at which an IR seeker can see a target depends on the intensity of IR-radiation emitted by the target in the direction of the sensor and the seeker sensitivity. Therefore, the track range of the IR seeker depends very much on the engine operating mode of the aircraft being tracked and on the aspect angle, reaching its maximum value for attacks in the rear quarter.

The figure below presents a diagram of the IR-radiation intensity by a single-engined aircraft in the horizontal plane.

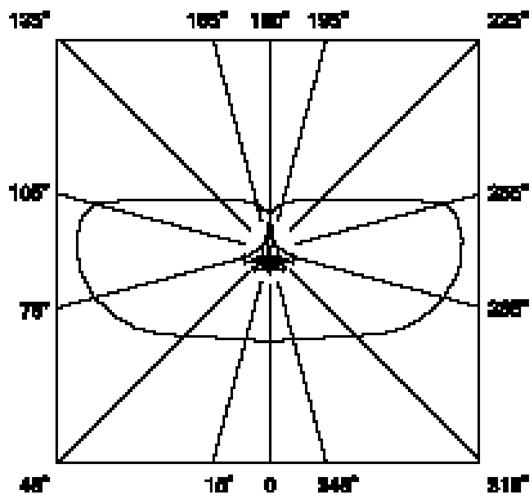


After the launch, a missile using passive homing becomes completely autonomous and is known as "fire-and-forget". If an IR seeker provides tracking of a target at any aspect angle, the seeker is said to be all-aspect, otherwise it is a rear-aspect seeker.

One of the major drawbacks of passive homing is its dependence on a "cooperative" target that continues to emit the energy required for homing. Besides, IR energy is absorbed and dissipated by water vapour, making heat seekers all but useless in clouds or rain. Discrimination between the target and background radiation generated by the sun, reflections off water, snow, clouds and hot terrain such as deserts can also be a problem for IR seekers.

Semi-active and active homing

For semi-active and active homing, a missile uses a radar seeker head. Radar-guided missiles are currently the most widely used all-weather AAMs. Here the power of radio emission from a target and the sensitivity of the receiver determine the missile's ability to track the target. As this case involves reflected radiation, its intensity depends on the power of the illuminating source and on the target's ability to reflect radio waves. This ability significantly depends on the aspect angle of the target. The figure below shows a typical diagram of reflected signal intensity:



Besides aspect angle, the reflection of radio waves depends on the size, shape and details of construction of the target.

Although semi-active homing provides acquisition of uncooperative targets and is good for long distances, one of its major problems is greatly increased complexity which results in reduced reliability. Essentially this technique requires two separate tracking systems to be successful (one in the missile, the other in the guidance platform). Another serious drawback is the requirement for target illumination by the guidance platform throughout the missile's flight. This requirement makes the illuminator vulnerable to passive-homing weapons, and with airborne illuminators it often restricts the manoeuvring option of the aircraft providing target illumination.

Although active homing requires a more complex, larger and more expensive missile, the total guidance system is no more involved than that of the semi-active system, and in some ways it is simpler and more reliable. It also gives the launching platform "fire-and-forget" capability, as do passive systems. One disadvantage, however, is the possibility of reduced target detection and tracking ranges. Since the range of target acquisition is proportional to the area of the illuminating antenna, all other factors being equal, the tracking range of the aircraft radar greatly surpasses that of the missile. Therefore, semi-active homing is possible at considerably greater distances than active homing. That is why active homing is frequently used in a combination with inertial guidance or semi-active homing and sometimes passive homing.

Target tracking

A variety of guidance laws are implemented in modern AAMs. Most missiles that employ proportional navigation techniques require a moveable seeker to keep track of the target. Such seekers have physical stops in all directions, called gimbal limits, which restrict their field of vision and therefore limit the amount of lead the missile may develop. If the seeker hits the gimbal limit, the missile usually loses its guidance capability, i.e. "goes ballistic". Such a situation most often develops when the line of sight to the target moves fast and the missile's speed advantage over the target is low.

Using onboard systems, the pilot searches, detects and acquires a target, then feeds the targeting data into the selected weapon. The missile can be launched if the current targeting data fit the characteristics of the guidance system of the chosen type of missiles. (For example, the aspect angle to the target falls within the gimbal limits of the seeker, and the intensity of radiation from the target is within the sensitivity limits of the seeker).

The pilot can launch the missile when it falls within the limits of the possible launch zone, which is usually calculated by the aircraft's onboard computer. The computer displays on the HUD information about the maximum and minimum range of launch and lights the '**ПР**' shoot cue (Russian designation for Launch Allowed, pronounced 'pe-er') when the missile is ready.

Target destruction

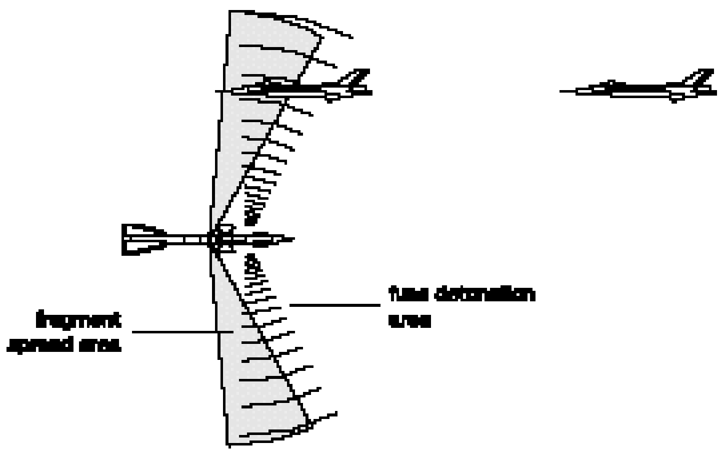
The warheads used in AAMs are typically blast-fragmentation; incendiary or explosive pellets, or expanding-rod types. Blast fragmentation warheads cause damage through the combined effects of the explosive shock wave and high-velocity fragments (usually pieces of the warhead casing). Pellet designs are similar, except some of the fragments are actually small bomblets that explode or burn on contact with, or penetration of, the target. The damage to airborne targets from blast effect alone is not usually great unless the missile actually hits the target. Fragments tend to spread out from the point of the explosion, rapidly losing killing power as miss distance increases. Pellets reduce this problem somewhat since a single hit can do more damage. The expanding-rod warheads have metal rods densely packed on the lateral surface of an explosive charge in one or several layers. The ends of these rods are welded in pairs so that while spreading after the explosion of the charge they form a solid extending spiral-shaped ring.

The lethality of a warhead depends largely on the amount of explosive material and the number and size of the fragments. Larger expected miss distances and imprecise fuses require bigger warheads. The greater the weight of the warhead, the more effectively it destroys the target. However, the larger the warhead the greater the overall weight of the missile and hence the less manoeuvrable it is.

The missile fuse induces the detonation of the warhead at the time that produces the maximum target damage. Fuses can be classified as contact, time delay, command, and proximity. Contact fuses are activated upon contact with the target. This type of fuse is often used in combination with another type. Time-delay fuses are pre-set before launch to explode at a given time that is calculated to place the missile in the vicinity of the target. Command fuses are activated by radio commands from the guidance platform when the tracking system indicates that the missile has reached its closest point to the target.

Modern AAMs mostly use proximity fuses which are probably the most effective against manoeuvring targets. They come in many designs including active, semi-active, and passive. An active fuse sends out some sort of signal and activates when it receives a reflection from the target. Semi-active fuses generally function on an interaction between the guidance system and the target. Passive fuses rely for their activation on a phenomenon associated with the target. This might be noise, heat, radio emissions, etc.

Proximity fuses are usually tailored to the guidance trajectory of the missile, the most probable target, and the most likely intercept geometry. They determine the closure rate, bearing, distance to the target, and other parameters. This ensures high combat efficiency of the warhead by rationally matching a fuse detonation area and a fragment spread area generally forming a cone-shaped lethal volume ahead of the warhead detonation point.



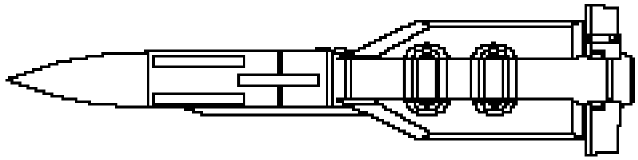
Fuse detonation and fragment spread areas

Note that modern AAMs contain a self-destruct mechanism in case the missile goes ballistic or loses control.

The pilot selects a particular type of missile depending on distance to the target and its manoeuvrability. Considering these characteristics, AA missiles can be divided into long-range, medium-range, and close air combat missiles.

Long range missiles

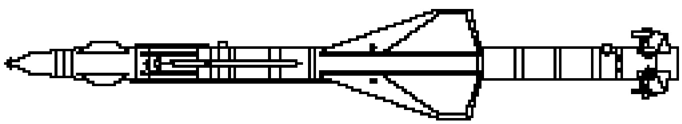
R-33E



The R-33E (USA/NATO designation: AA-9/'Amos') designed by the Vympel OKB is a long range guided missile with an operating range up to 160 km. The missile employs inertial control and semi-active radar guidance on the terminal segment of flight. The R-33E is used to intercept aircraft and cruise missiles, that is why it is the principal missile of the MiG-31 Foxhound. The missile is capable of destroying targets ranging in altitude from 25 m to 28 km and flying at speeds up to Mach 3.5. Relative difference in altitudes of the missile and the target can be up to 10 km. The R-33E flies at Mach 4.5.

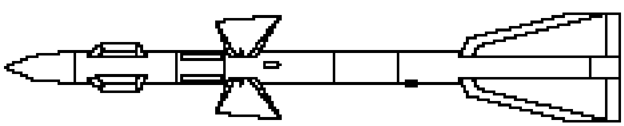
Medium range missiles

R-23



The Vympel R-23 (AA-7 'Apex') medium-range missile comes in two modifications, which differ in the seeker type. The R-23R ('AA-7A') has a semi-active radar seeker while the R-23T ('AA-7B') has an IR seeker. Both the missiles have a maximum range of about 25-35 km. Nowadays, the R-23 is often replaced by the more powerful and intelligent R-27 'Alamo'.

R-27

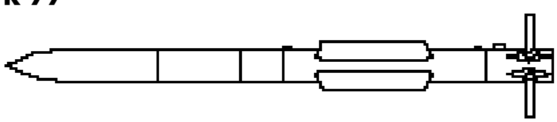


The Vympel R-27 (AA-10 'Alamo') is the primary medium-range AAM for the Su-27 and is available in several variants. The R-27 entered production in 1982 specifically for use on the new MiG-29 and Su-27 then drawing close to service entry, in place of the R-23 'Apex' used by the MiG-23. The R-27 is effective against highly manoeuvrable aircraft, helicopters, and cruise missiles. It can destroy targets at any aspect angle, both in daylight and at night, in good or bad weather. Its guidance system is resistant to natural interference and ECM, and capable of tracking targets against ground and water clutter. The R-27 can engage targets ranging in altitude from 25 m to 20 km with elevation up to 10 km. The targets can fly at speeds up to 3500 km/h and with g-load up to 8 Gs.

The R-27 has a large number of versions equipped with various seeker heads. The basic semi-active radar homing (SARH) version is the R-27R ('Alamo-A'), often carried in conjunction with an R-27T ('Alamo-B') IR-homing missile so that pairs of SARH and IR-homing missiles can be "ripple-fired" for improved kill probability. Long-range versions of both missiles have a new boost sustain motor and are externally recognisable by their increased body length and a slightly "fattened" rear fuselage. These are designated R-27Re and R-27TE respectively. Two other variants are the R-27EM with an improved SARH seeker for better performance against low-flying and sea-skimming missiles, and the R-27AE with active radar terminal homing. The Su-27 standard warload includes six R-27s.

Version	Guidance	Range, km
R-27R	Inertial radio-corrected guidance and semi-active radar terminal homing	80
R-27T	All-aspect passive infrared homing	70
R-27RE	The same as in R-27R	100
R-27TE	The same as in R-27T	100
R-27EM	Inertial radio-corrected guidance and semi-active radar terminal homing (able to destroy cruise missiles at a height of 3 m above water surface)	70
R-27AE	Inertial radio-corrected guidance and active radar terminal homing	70

R-77

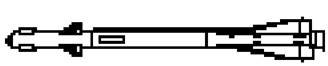


The Vympel R-77 (AA-12 'Adder') is a new-generation medium-range AAM. This missile is unofficially dubbed "AMRAAMski" in the West. The R-77 entered limited production in 1992 and is primarily intended for the new advanced versions of the Su-27 and MiG-29. The missile employs radio command guidance on the initial part of flight and active radar homing on approach to the target (15 km and less). The monopulse-Doppler active seeker is developed by the Agat NII.

The R-77 can be effectively used against highly manoeuvrable aircraft, cruise missiles, AAMs and SAMs, strategic bombers, helicopters (including helicopters in hover mode). It can destroy targets moving in any direction and at any aspect angle, in daytime and at night, in good or bad weather. Its guidance system is resistant to ECM and is capable of tracking targets against ground and water clutter. Maximum operating range is 90 km. The missile can attack targets at aspect angles up to 90°. The R-77 normally flies at Mach 4.5.

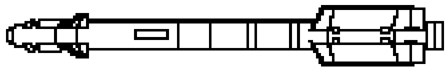
Close air combat missiles

R-60



The R-60 (AA-8 'Aphid') missile is a close air combat missile with all-aspect infrared passive homing. The maximum operating range is 10 km. The missile normally flies at Mach 2. The R-60 can be carried by practically any Russian combat aircraft and by many helicopters, though it is now considered obsolete and often replaced by the more intelligent R-73.

R-73



The Vympel R-73 (AA-11 'Archer') was developed as a replacement for the R-60 and is the first of a new generation of highly manoeuvrable missiles for close air combat. The missile employs IR passive homing and has been described as being "a decade ahead of current Sidewinder" variants, and as the most sophisticated IR-guided AAM in service. The R-73 has a new level of agility and is capable of off-axis launch from all aspects. It has a very wide-angle sensor which can be slaved to the pilot's helmet-mounted sight, allowing the missile to be locked up at targets up to 60° from the aircraft axis. The missile can be launched from aircraft pulling up to 8.5 Gs.

The R-73 employs aerodynamic control combined with vectored thrust. Tremendous manoeuvrability (up to 12 Gs) is conferred by the missile's combination of forward-mounted canard fins, rudderons on the fixed tailfins and deflector vanes in the rocket nozzle.

The missile has a 7.4 kg expanding rod warhead and can destroy targets at altitudes of as low as 5 metres and at ranges up to 30 km. The R-73 normally flies at Mach 2.5.

The table below contains the comparative characteristics of various types of modern Russian AAMs. The maximum number of a specific type of weapon that can be carried is shown next to the aircraft designation in parenthesis.

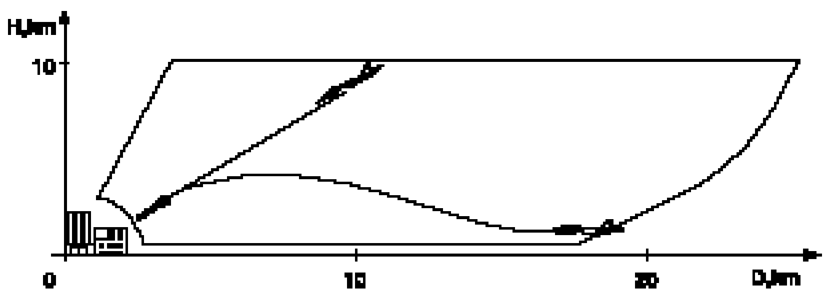
Type	USA/NATO	Carrier (#)	Weight, kg	Seeker	Range, km
R-23R	AA-7A/Apex	MiG-23 (2)	223	SARH	35/25
R-23T	AA-7B/ Apex	MiG-23 (2)	217	IR	35/25
R-27R	AA-10A/Alamo-A	MiG-29 (4), Su-27 (6)	253	SARH	80
R-27T	AA-10B/Alamo-B	MiG-29 (4), Su-27 (6)	254	IR	70
R-27RE	AA-10C/Alamo-C	MiG-29 (4), Su-27 (6)	350	SARH	130
R-27TE	AA-10D/Alamo-D	MiG-29 (4), Su-27 (6)	343	IR	120
R-33A	AA-9/Amos	MiG-31 (6)	490	SARH	160
R-60	AA-8/Aphid	Su-24 (2), Su-25 (2), MiG-23 (4), MiG-27 (2)	45	IR	10
R-73	AA-11/Archer	MiG-29 (6), MiG-31 (4), Su-24 (2), Su-25 (2), Su-27 (10)	110	IR	40

Type	USA/NATO	Carrier (#)	Weight, kg	Seeker	Range, km
R-77	AA-12/Adder	MiG-29 (6), MiG-31 (4), Su-25 (2), Su-27 (10)	175	radio command +ARH	150

Air-to-ground Missiles

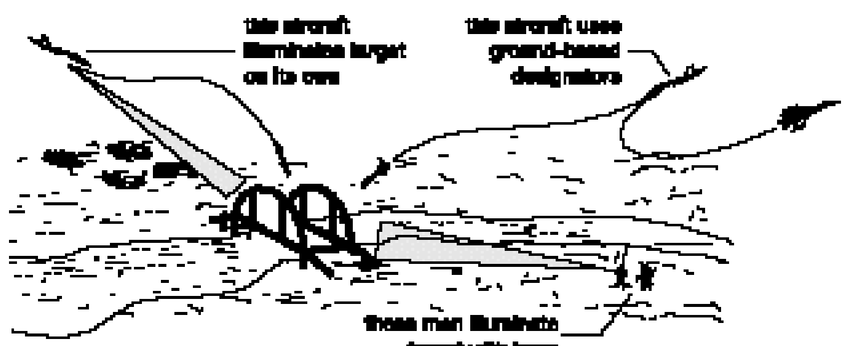
General purpose tactical missiles

General purpose tactical missiles include the Kh-29 and Kh-25 families. These missiles can destroy field fortifications, railway and highway bridges, runways, bunkers, fortified missile launchers, ships and surfaced submarines. The missiles are powered by solid-propellant rocket motors, which have a burn of some seconds and ensures initial boost up to speeds of about 800-900 km/h. The figure below shows a typical launch envelope for the Kh-29 missile.



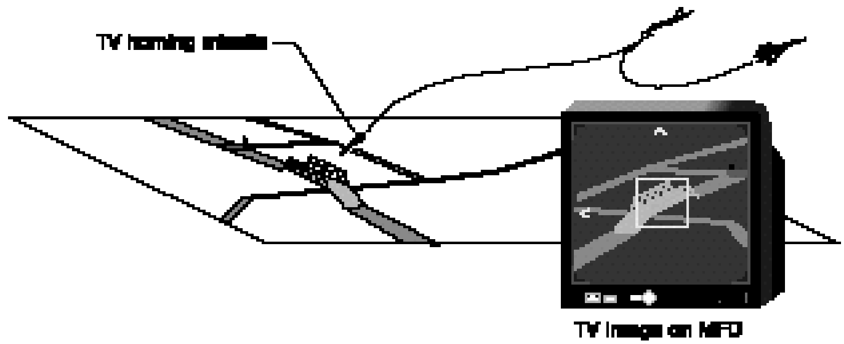
Launch envelope of the Kh-29

To guide an air-to-ground missile, passive homing (TV or IR) or semi-active homing (radar or laser) can be employed. In case of semi-active homing, a target is illuminated by aircraft equipped with special opto-electronic systems, or by ground-based laser designators. The seeker head locks onto the illuminated target before missile launch.



Using an ASM with semi-active homing

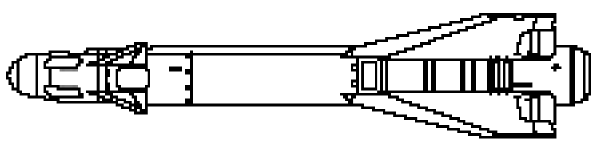
With passive homing (see the figure below), the seeker head receives a television (TV) or thermal (IR) image of the terrain and then separates the target from the background. The characteristics of the target and underlying surface (luminance contrast or heat contrast of a target) determine the guidance feasibility. Missiles with TV homing are mainly used in daytime in conditions of fair visibility, while those with IR homing in conditions of poor visibility and at night. Note that the use of thermal imaging in clouds is nearly impossible due to the "insulation" effect of water. Before launching the missile, the pilot locks its seeker onto the target; in so doing, the image of the target appears on the MFD.



Using an ASM with passive homing

The main modifications of the Kh-25 and Kh-29 missile families are:

Kh-29

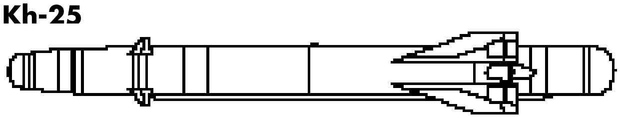


The most common air-to-ground guided missile is the Kh-29 (AS-14 'Kedge') designed by the Zvezda (Star) OKB and intended for destroying hardened targets such as reinforced concrete shelters, concrete runways, major railway and highway bridges and sea-based targets, ships and surfaced submarines). The launch altitude lies between 200 metres and 5 km. Maximum launch range for the Kh-29 is about 10-12 km and maximum speed is 3000 km/h. The Kh-29 comes in the following major versions:

Version	Guidance	Warhead, kg	Range, km
X-29L	Semi-active laser homing	317	8-10
X-29T	TV homing.	320	20-30

The Kh-29T fire-and-forget version is capable of destroying large tonnage ships (up to 10000-ton displacement) such as torpedo boat or cruiser.

Kh-25



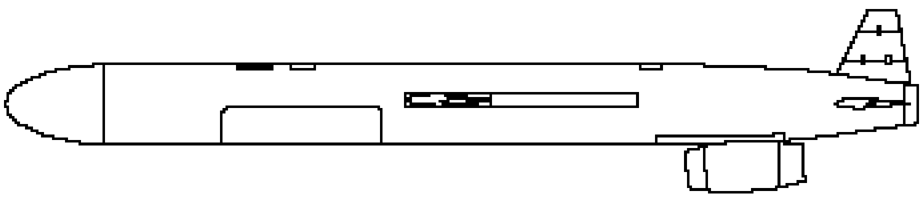
The Zvezda Kh-25 (AS-9 'Karen') is another widely used ASM. Its area of application is similar to that of the Kh-29 missile. The Kh-25 family includes a large set of modifications. The table below contains specifications for two versions of the Kh-25 missile:

Version	Guidance	Warhead, kg	Range, km
X-25T	Passive IR homing	90	2-20
X-25L	Semi-active laser homing	90	10-20

The X-25L missile, fitted with a laser guidance system, is designed to engage a wide range of small targets, such as radar sites, command posts and tactical missile launchers. In terms of performance characteristics it can be compared to the American AGM-65E 'Maverick'. The target under attack can be illuminated by both the airborne and ground-based designation stations.

All the Kh-25 missiles share a common aerodynamic configuration and are fired from an APU-68 airborne launcher. The missiles can fly at up to 3200 km/h.

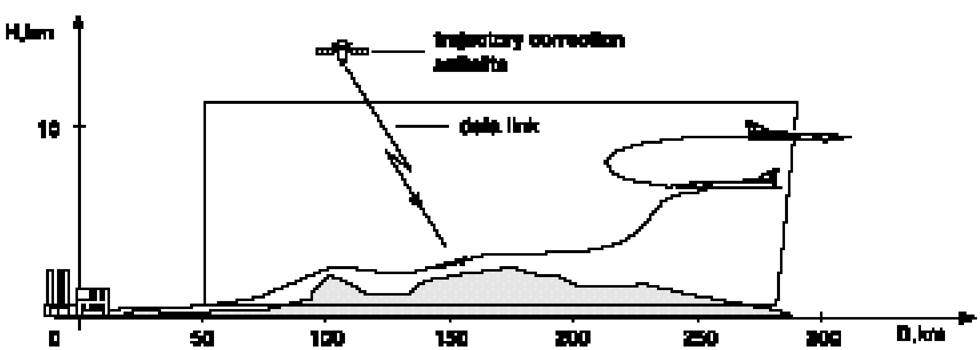
Kh-55



The Kh-55 (AS-15 'Kent') designed by the Raduga (Rainbow) OKB is a subsonic cruise missile flying at Mach 0.5-0.75. The missile can destroy fixed ground targets with known coordinates at ranges up to 300 km.

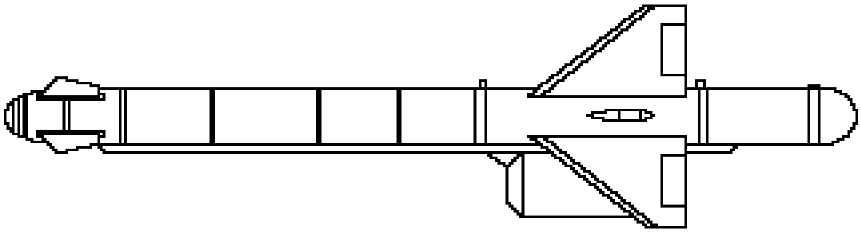
The Kh-55 is fitted with a dual-flow turbojet engine. It's inertial guidance with terrain following integrated with a satellite navigation system allows the missile to fly at altitudes of 40-110 metres and to hit targets with an accuracy of 18-26 metres.

This missile can be launched from a beam or drum launcher. After the launch, the Kh-55 flips out the wings and lowers the engine from its body, then descends to an altitude of about 100 metres. Typically, the pilot can launch the Kh-55 missile at a range of 50-250 km and at altitudes of 200-12000 m. The missile's trajectory can be corrected by the satellite.



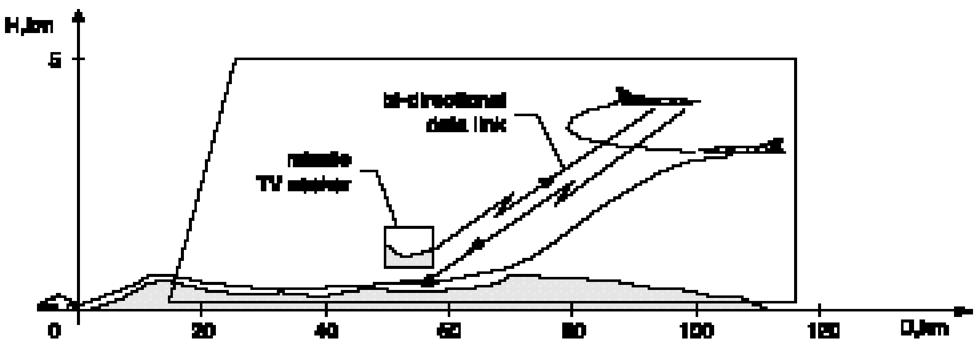
Launch envelope of the Kh-55

Kh-59



The Kh-59 (AS-13 'Kingbolt') is a tactical missile intended for destroying targets with known coordinates and located at ranges up to 200 km from the point of launch. The dual-flow turbojet engine allows the missile to fly at a cruising speed of about 1000 km/h maintaining an altitude of 100 metres above the ground. The Kh-59 uses inertial guidance during the main part of flight and TV homing on approach to the target.

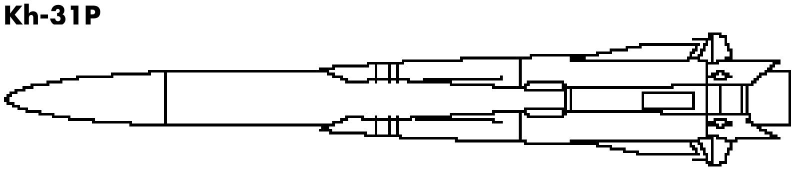
The navigator onboard the launching aircraft receives the image of the terrain seen by the missile's TV seeker, and can correct the missile's trajectory using the map stored onboard . When the Kh-59 approaches the target area, the navigator identifies the target and guides the missile directly to it. This method ensures very high accuracy (about 2-3 m).



Launch envelope of the Kh-59

Anti-radar missiles

Kh-31P



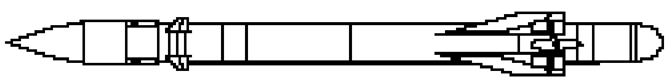
The Zvezda Kh-31P (AS-12 'Kegler') anti-radar missile effectively destroys all existing types of long-range and medium-range air defence radar, air traffic control radar, and early warning radar. The Kh-31P was created to overcome air defences, in particular those equipped with the 'Patriot' air defence missile system.

The Kh-31P uses an integral powerplant fitted with a combined solid-propellant/ramjet engine developed by the OKB Soyuz (Union). The combustion chamber of the mid-flight ramjet engine houses a solid-propellant booster which, after the Kh-31P leaves the aircraft, accelerates the missile to the ramjet sustainer minimum ignite speed (about 1000 km/h). After the booster has finished its task, it is ejected from the combustion chamber of the ramjet sustainer.

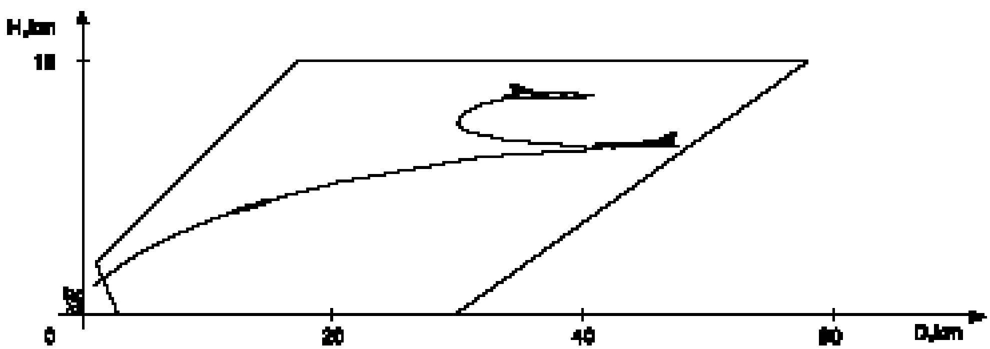
The Kh-31P is arguably the most sophisticated missile of its type currently in service. It can gain the upper hand of any enemy SAM launcher in a "duelling situation" as its high speed makes the missile hard to detect. The missile uses a passive radar seeker capable of acting in a broad band of frequencies. The onboard electronic equipment of the Kh-31P can employ several seeker modes including automatic search and guidance mode. After launch the missile is completely autonomous.

The Kh-31P missile can fly at a maximum speed of about 4700 km/h. Typically, the pilot can launch the missile at ranges of 5-100 km and at altitudes of 50-15000 m.

Kh-25MP



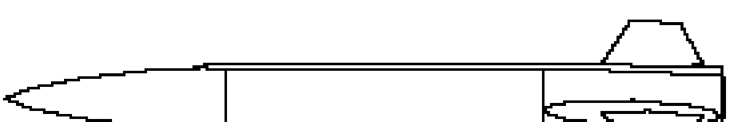
The Zvezda Kh-25MP (AS-10 'Karen') anti-radar missile belongs to the Kh-25 family, has a passive radar seeker and engages enemy radar at a distance of 40-60 km. The maximum speed of the missile is about 3200 km/h. The Kh-25MP can be compared to the American 'Harm' missile, however it has a more powerful warhead and slightly shorter range.



Launch envelope of the Kh-25MP

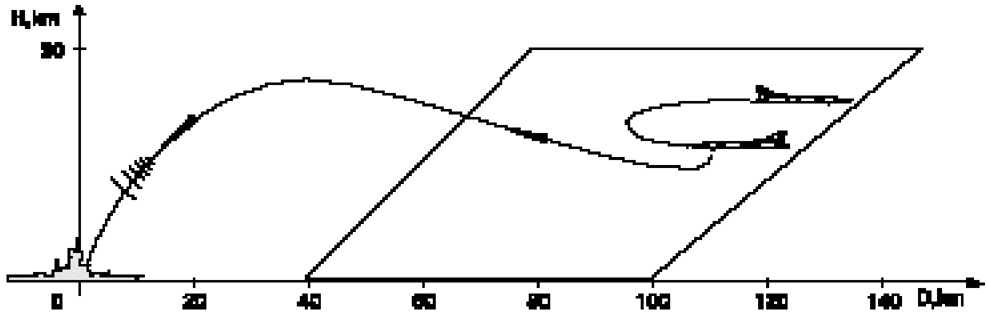
Anti-ship missiles

Kh-15



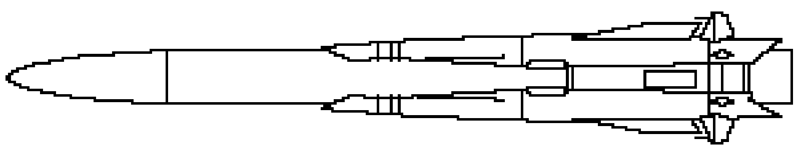
The Kh-15 (AS-16 'Kickback') is a supersonic aeroballistic missile intended for destroying ships such as cruisers or destroyers. The missile has a solid-propellant rocket motor. During cruise flight (normally, at Mach 5), the missile climbs, and at the terminal part of flight it follows a ballistic trajectory.

The Kh-15 is fed targeting data by the launch platform and uses inertial guidance and active radar homing at the terminal part of flight. It has a launch range from 50 to 160 km. This missile can be launched from a beam or drum launcher.



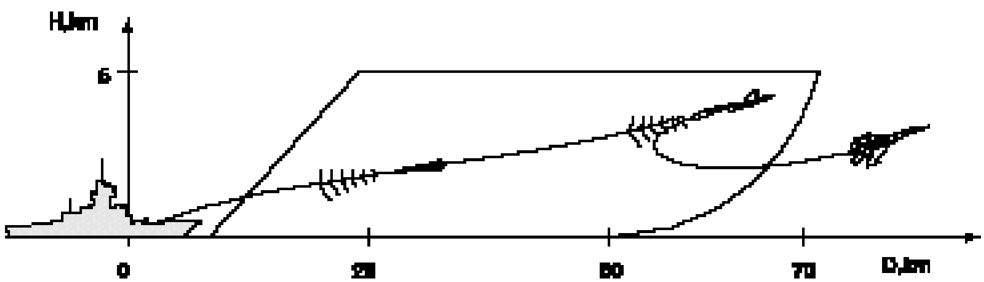
Launch envelope of the Kh-15 anti-ship missile

Kh-31A



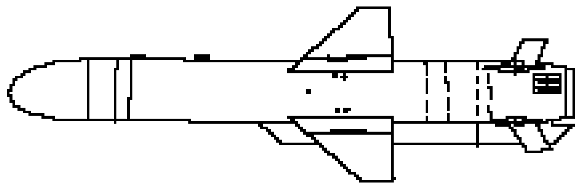
The construction of the Zvezda Kh-31A (AS-12 'Kegler') supersonic anti-ship missile is similar to that of the Kh-31P. The Kh-31A employs an active radar homing system, and a more powerful warhead. The missile can be launched at stand-off ranges and is capable of destroying targets in conditions of ECM and under any meteorological conditions.

The Kh-31A is fitted with a 90-kg piercing warhead to effectively destroy surface vessels with displacement of up to 4,500 tons. Typically, the pilot launches the Kh-31A at ranges of 5-60 km and at altitudes of 50-15000 m.



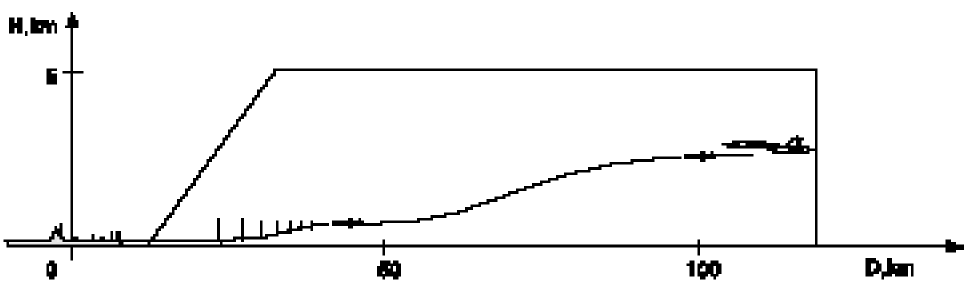
Launch envelope of the Kh-31A

Kh-35



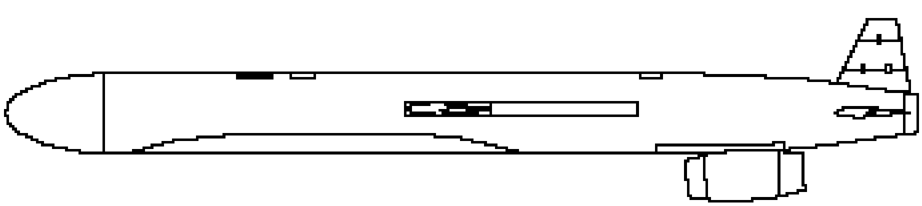
The Zvezda Kh-35 (AS-17 'Krypton') is an anti-ship missile flying at transonic speeds (1100 km/h). The Kh-35 has a two-stage configuration: the missile is fired from the launcher by a solid-propellant motor, then the small-size cruise turbojet engine, operating on aviation kerosene, takes over its sustainer flight. For better handling, the size of the missile was reduced by creating folding wings, control surfaces and stabilisers. The aerodynamic surfaces of the missile open up as soon as it leaves the launching platform.

The Kh-35 employs combined guidance: during the initial part of flight an inertial guidance system guides the missile to a pre-programmed point provided by the navigation system or AWACS. In the terminal part of flight, the missile engages its active radar homing system, which can work in conditions of severe ECM and enemy fire. The missile cruises at extremely low altitudes (3-5 metres, depending on sea conditions), which greatly hampers interception by shipborne antimissile systems. The 145-kg piercing blast-fragmentation warhead allows reliable engagement of surface vessels up to cruiser class. The missile is normally fired at a stand-off range within its launch envelope (see the figure below).



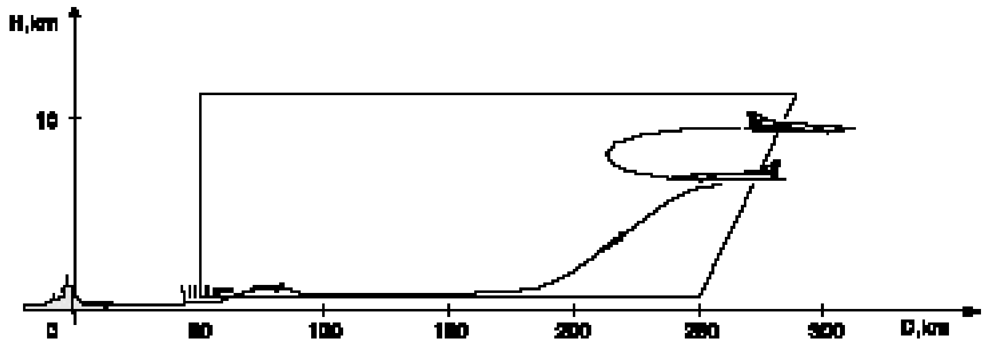
Launch envelope of the Kh-35

Kh-65



The construction of the Kh-65 (NATO and USA designations are unknown) anti-ship missile is similar to that of the Kh-55. The Kh-65 can destroy ships such as cruisers or destroyers using targeting data relayed from the launch platform.

The missile can engage targets stand-off, without the launching aircraft entering into the ships air defence area. While cruising, the Kh-65 travels at altitudes of 40-110 metres at Mach 0.5-0.75. Unlike the Kh-55, the Kh-65 switches to homing upon approach to the target. For this purpose it has an active radar seeker, ensuring high precision guidance on the final approach to the target. Typically, the pilot can launch the Kh-65 missile at ranges of 50-250 km and at altitudes of 200-12000 m. This missile can be launched from a beam or drum launcher.



Launch envelope of the Kh-65

The table below contains the main characteristics of various types of Russian ASMs.

Type	USA/NATO	Carrier (#)	Weight, kg	Range, km	Targets
Kh-15	AS-16/Kickback	Tu-95 (6), Tu-142 (6), Tu-22M3 (8)	1200	150	ships
Kh-25MP	AS-9/Karen	MiG-27 (2)	300	10	radar
Kh-25MT	AS-9/Karen	MiG-27 (2), Su-24 (4), Su-25 (4) targets	300	20	ground
Kh-25MTL	AS-9/Karen	MiG-27 (2), Su-24 (4), Su-25 (4)	300	20	ground targets
Kh-29T	AS-14/Kedge	MiG-27 (2), Su-24 (3), Su-25 (4), Su-27 (4)	680	12	ground targets, ships

Type	USA/NATO	Carrier (#)	Weight, kg	Range, km	Targets
Kh-31P	AS-12/Kegler	MiG-27 (2), Su-24 (2), Su-25 (2), Su-27 (6)	600	100	radar
Kh-31A	AS-12/Kegler	MiG-27 (2), Su-25 (2), Su-27 (6)	600	50	ships
Kh-35	AS-17/Krypton	MiG-27 (2), Su-27 (6), Tu-142 (8)	600	130	ships
Kh-55	AS-15/Kent	Tu-95 (4)	1250	300	ground targets
Kh-59	AS-13/Kingbolt	Su-24 (2)	920	115	ground targets
Kh-65	Unknown	Tu-142 (6)	1250	280	ships

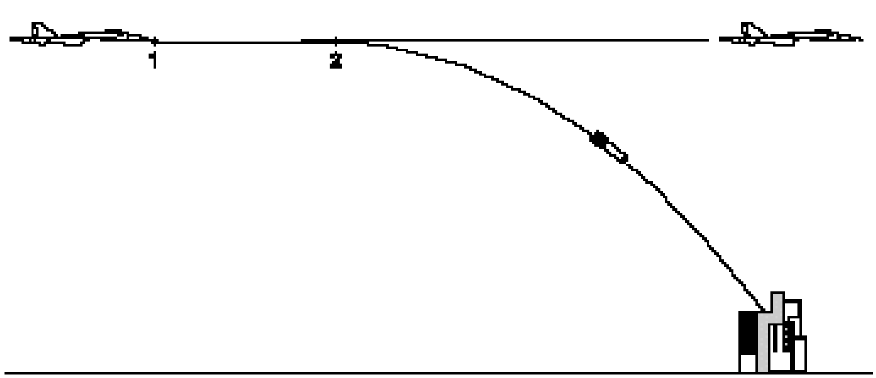
Bombs

Bombs are used for destroying comparatively large and fortified targets. After the release the bomb either follows a ballistic trajectory (free-fall bombs), or moves under control of its guidance system (guided bombs).

A typical bomb consists of a cylindrical body equipped with stabilisers, a charge of explosive, and a fuse. The most common bombs are blast (Russian designation FAB), fragmentation (OAB), concrete piercing (BetAB) and incendiary (ZAB) bombs, and combined action bombs, for example, blast-fragmentation (OFAB) bombs. All these types of bombs can be monolithic or cassette.

There are various methods of placing bombs on the target: laydown bombing, dive bombing, dive/pull-up bombing, and loft bombing.

Laydown bombing

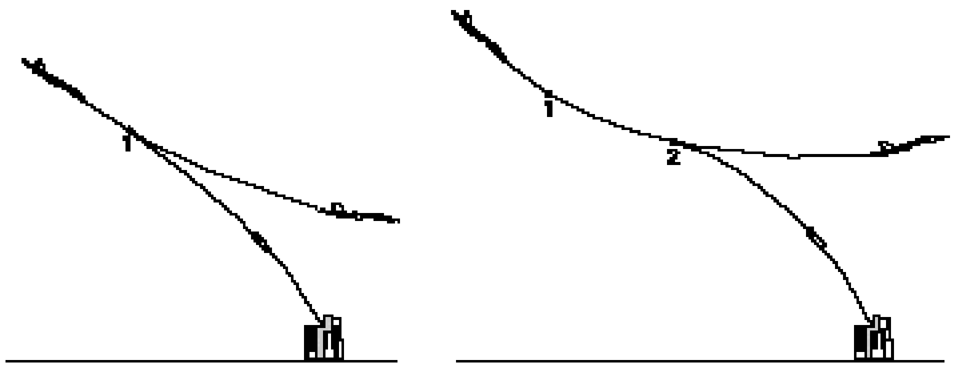


Laydown bombing

For laydown delivery, bombs are released with the aircraft flying straight and level or at a small climb or dive angle. In so doing, the pilot can pinpoint a target using various methods. One of them is to place the bombsight onto a visible target and lock onto it thereby providing the targeting data to the onboard computer (Point 1 on the figure above). The computer then starts continuously computing the coordinates of the target, the bomb impact point (CCIP), and the misalignment between them in horizontal angle and range. The pilot should line up the aircraft with the target designator (in order to zero the misalignment) and release the bombs as soon as the bombsight crosses the release point (Point 2). For more information on bombing, turn to Chapter 6, "Hitting Ground Targets".

Dive and dive/pull-up bombing

For dive bombing, the pilot drops the bombs executing a dive manoeuvre, that is, when the aircraft flies at a constant (or slowly changing) dive angle. For dive/pull up bombing, bombs are released during the recovery from the dive.



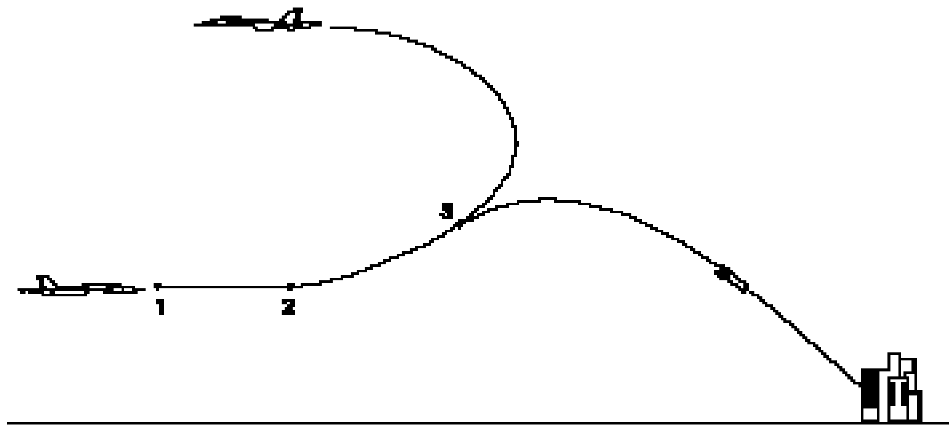
Dive bombing (left) and dive/pull up bombing (right)

For dive bombing (left), it is necessary to fly the aircraft so that the bombsight pipper sets right on the target until the '**ПР**' Shoot Cue illuminates. Then the pilot pulls the trigger and releases the bombs. The pilot should pay special attention to the safety of his aircraft after the release of bombs to prevent both crashing to the ground, and being damaged by debris as the bombs detonate.

Dive/pull up bombing (right picture) is normally carried out in two steps. At the first step, the pilot adjusts his trajectory so that the aircraft heads right for the target (Point 1). At the second step he pulls the aircraft up from the dive staying lined up on the target and releases the bombs as soon as the range misalignment between the impact point and the targets reduces to zero (Point 2).

Loft bombing

Loft bombing is sometimes called toss bombing, because the bombs are thrown rather than dropped.



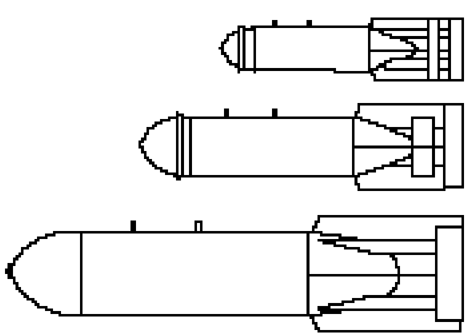
Loft bombing

For loft attacks, target data must be downloaded to the onboard computer (Point 1) in the same way as in laydown bombing. The aircraft pulls up into a climb (approximately 30° nose up) a good way out from the target about 20 units of time on the countdown (see Point 2). In so doing, the pilot remains on course to the target. The bombs are released in the climb (Point 3) on countdown zero. The aircraft can now leave the bombing zone, while the bomb follows a parabola trajectory to the target.

This method gives the aircraft more time to leave the impact point and extends the bomb delivery range.

Free-fall bombs

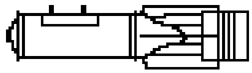
FAB-250, FAB-500, FAB-1500 general purpose bombs



The FAB-250, FAB-500, FAB-1500 general purpose bombs contain charges of high explosive. FAB stands for Blast Aviation Bomb in Russian, and the number in the bomb designation denotes its calibre in kilograms: 250, 500, and 1500 kg, correspondingly. These bombs damage targets mainly by shock wave, and they are effective against defence facilities, industrial facilities, railway junctions, ships, and soft targets.

General purpose bombs are the cheapest of all major air-to-ground munitions and can be delivered using any of the bombing methods described above. For effective delivery it is desirable to release general purpose bombs at a speed of 500-1000 km/h and at altitudes of 300-5000 m.

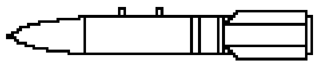
OFAB-250 blast-fragmentation bomb



The OFAB-250 is a 250-kg blast-fragmentation bomb (OFAB stands for Blast Fragmentation Aviation Bomb in Russian) that combines the effects of both the general purpose and fragmentation bombs. The blast results in forming a large cloud of small fragments.

This weapon is effective against personnel and lightly armoured vehicles. It is released at airspeeds from 500 to 1000 km/h and at altitudes from 500 to 5000 metres using any delivery method.

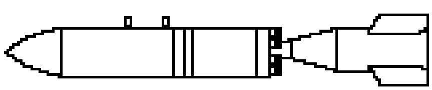
PB-250 retarded bomb



The PB-250 is a blast-fragmentation retarded bomb weighing 250-kg and fitted with an aft bay containing a drogue chute deployed when the bomb is released. The parachute increases air resistance of the bomb and, consequently, greatly reduces its speed. This allows the pilot to bomb from low altitudes, since the aircraft will have enough time to leave the dangerous area of flying debris and bomb fragments.

The bomb contains a blast-acting charge, the required fragmentation being provided by special design of the bomb casing. The PB-250 is effective against personnel, lightly armoured vehicles, truck convoys, parked aircraft on airfields, etc. Delivery should be as for laydown bombing from altitudes of 100-300 metres and at airspeeds of 500-1000 km/h.

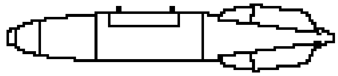
BetAB-500ShP concrete-piercing bomb



The BetAB-500ShP concrete-piercing bomb (BetAB stands for Concrete-Piercing Aviation Bomb in Russian) is a special purpose bomb and is effective against reinforced concrete bunkers and runways. As opposed to a general purpose bomb, the BetAB has a stronger frame and a hardened nose. Due to these distinctions and given sufficient kinetic energy, the bomb penetrates through concrete and then explodes. The BetAB-500ShP is fitted with a drogue chute and a solid-propellant booster. The parachute initially slows the bomb down giving the aircraft more time to clear the impact zone. The parachute is then released as the booster ignites accelerating the bomb to the speed necessary to penetrate hardened concrete.

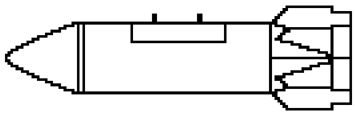
To deliver the BetAB-500ShP, the pilot uses the laydown bombing technique from altitudes of 150-500 m at airspeeds from 550 to 1100 km/h.

ZAB-500 incendiary bomb



The ZAB-500 is an 500-kg incendiary bomb (ZAB stands for Incendiary Aviation Bomb in Russian) intended for destroying enemy personnel, industrial facilities, railway stations, etc. Its casing is filled with a combustible mixture based on thickened petrochemicals. To spread viscous mixture and ignite it, the bomb uses a bursting charge and an igniting cartridge.

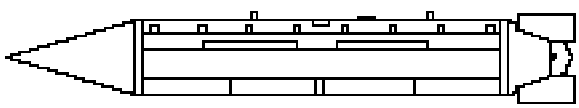
RBK-500 cluster bomb



Cluster bomb dispensers are actually thin-walled casings containing small-sized (weighing up to 25 kg) fragmentation, antitank, incendiary, concrete-piercing bomblets. The casings have the overall dimensions of general purpose bombs of 250- or 500-kg calibre.

Release of the RBK-500 bomb (RBK stands for Expendable Bomb Cassette in Russian) arms a proximity fuse, which detonates within pre-set time at a pre-set altitude. The casing breaks apart into two halves and ejects the bomblets in a dense cloud. The bomblet impacts cover an area which depends on the speed and altitude at which the casing breaks apart. Thus, unlike a usual bomb, a cluster bomb destroys targets in a considerably wide area. Delivered at low altitude for maximum effect.

KMGU

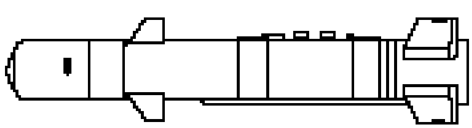


Bomblets can also be dispensed from an aircraft-mounted multi-purpose nondrop pod (Russian designation KMGU stands for Unified Container of Small Loads). Such a pod consists of several compartments, typically, four. The pilot can dispense submunitions both simultaneously from all the compartments and successively from one compartment at a time. The submunitions should be dispensed in level flight at low altitudes (50-150 m) and at airspeeds of 500-900 km/h. A typical KMGU dispenser is shown in the figure above.

Guided bombs

Guided bombs are among the most effective and "smart" types of air-to-ground weapons, combining high efficiency of target destruction with relatively low cost. This kind of weapon is effective against fixed ground targets (railway bridges, fortifications, communications, junctions) and is fitted with a blast or armour-piercing warhead.

KAB-500 guided bomb

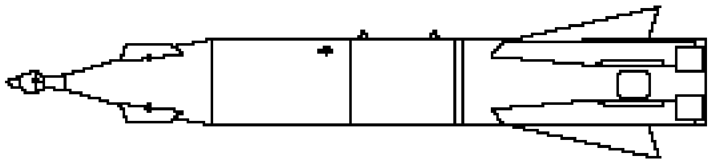


The KAB-500 guided blast bomb (KAB stands for Controlled Aviation Bomb in Russian) employs TV or IR homing. The TV-version of the bomb named KAB-500KR is normally used in daytime in conditions of fair visibility whilst the IR-version (KAB-500L) is mostly applied at night and against camouflaged targets. The warhead can be either armour-piercing or blast.

The TV seeker head includes a TV camera, a microprocessor and a power supply unit. The angular field of vision of the TV seeker is equal to 2-3°. After lock onto a target and release, the bomb becomes completely autonomous. To correct its trajectory, the bomb uses control surfaces, which ensure accuracy of about 3-4 metres.

The KAB-500 is normally delivered using a shallow dive bombing technique. Typically, the pilot releases this bomb at airspeeds of 550-1100 km/h and at altitudes of 500-5000 metres.

KAB-1500L



Front-line and long-range aircraft often carry the powerful KAB-1500L laser-guided bomb. It is effective against superhardened targets, hardened fortification installations, nuclear storage bunkers, strategic command centres, etc.

The KAB-1500L employs semi-active laser homing which provides impact accuracy of about 1-2 metres. The bomb is fitted with either a penetrating warhead (it pierces concrete covers having thickness up to 2 metres), or a explosive warhead (the blast can form a crater in excess of 20 metres in diameter). The pilot can employ the bomb at altitudes from 500 to 5000 metres while flying at airspeeds of 550-1100 km/h.

The table below contains specification of some popular bombs:

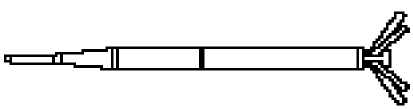
Type	Carrier (#)	Weight, kg	Warhead weight, kg	Warhead type
FAB-250, OFAB-250, PB-250	Su-27 (12), Su-24 (18), Su-25 (10), MiG-27 (8) MiG-29 (8), Tu-95 (60)	250	230	blast blast-fragm. blast-fragm.
FAB-500	Su-27 (6), Su-24 (8), Su-25 (8), MiG-27 (4) MiG-29 (4), Tu-95 (30)	500	450	blast
FAB-1500	MiG-27 (2), Tu-95 (18)	1400	1200	blast
BetAB-500ShP	MiG-27 (2)	425	350	concrete- penetrating
ZAB-500	Su-27 (6), Su-24 (7), Su-25 (8), MiG-27 (4), MiG-29 (4)	500	480	incendiary

Type	Carrier (#)	Weight, kg	Warhead weight, kg	Warhead type
RBK-500	Su-27 (6), Su-24 (8), Su-25 (8), MiG-27 (4), MiG-29 (4)	380	290	cluster/ fragmentation
KAB-500	Su-27 (6), Su-24 (4), Su-25 (8), MiG-27 (2)	560	380	armour-piercing or blast
KAB-1500L	Su-24 (2), MiG-27 (1)	1500	1100	blast

Unguided Rockets

Despite the existence of high accuracy weapons, unguided rockets remain the main type of air-to-ground weapon, combining high combat efficiency and simplicity of use with low cost.

An unguided rocket has a relatively simple design and consists of a fuse and a warhead in the nose part followed by the rocket body with a solid-propellant motor and stabiliser. A typical rocket (S-13) is shown in the figure below. Unguided rockets are usually placed in special rocket pods.



The rocket motor begins to operate at the moment of launch. Due to thrust provided by the motor, which usually operates from 0.7 to 1.1 seconds depending on the rocket type, the rocket accelerates to 2100-2800 km/h. After the motor burns out, the rocket coasts, gradually slowing down because of air resistance. Like a projectile, the unguided rocket follows a ballistic trajectory. To provide steady flight, a rocket has a stabiliser located in its tail part this serves to align the longitudinal axis of the rocket with its velocity vector. As unguided rockets are usually carried in launching pods, the stabiliser fins are kept folded inside the launch tubes of the pod. When the pilot launches the rocket, the stabiliser fins flip out into a fixed position.

Some types of unguided rockets stabilise by spinning themselves about the longitudinal axis. To spin, a rocket can utilise specially shaped stabiliser fins (for small calibre rockets), or rifled nozzles in the launch tubes. Angular velocity of rotation ranges between 450 rpms and 1500 rpms and develops within a short interval after the launch.

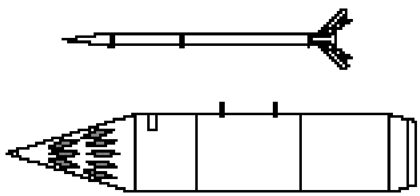
Depending on combat tasks, the pilot can employ unguided rockets of different calibre (from 57 mm up to 370 mm in diameter), fitted with fuses and warheads of appropriate types. A fuse can detonate on hitting the target, as, for example, in the case of an armour-piercing warhead, or at a certain distance from the launching platform, as in the case of a flare warhead.

Hit accuracy is characterised by an effective range, which depends on the type of unguided rocket. Since a rocket flies without any guidance, its accuracy decreases as the distance to the target increases.

Each type of unguided rocket has a specific possible launch zone limited by effective launch range, on the one hand, and by safety range, on the other. The safety range depends on the warhead type and weight and should prevent the launching aircraft from being damaged by the debris after the warhead explosion.

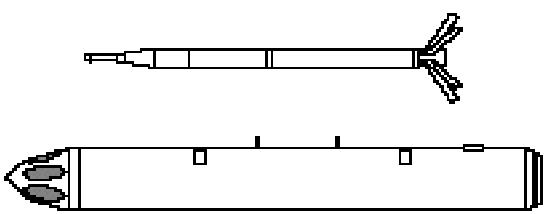
The pilot mostly employs unguided rockets at airspeeds of 600-1000 km/h while performing a dive at angles of 10-30°. By manoeuvring the aircraft, the pilot should line up on the target. Before the aircraft enters the rocket launch envelope, the pilot should place the Aiming Reticle on the target and on entering the launch envelope pull the trigger to launch.

S-8



The S-8 is a medium-calibre unguided rocket (80-mm in diameter) placed into the B-8 rocket pod (see figure above) each containing 20 rockets of this type. The S-8 has an effective range of 2000 metres. The hit accuracy is equal to 0.3% of launch range, that is, when you launch the rockets from a distance of 2000 metres, they hit within a circle of 6 metres in diameter. The S-8 is normally deployed with a shaped-charge fragmentation warhead effective against soft targets. The warhead can also be of fragmentation or armour-piercing type, which allows them to penetrate reinforced concrete of up to 0.8 metres in thickness.

S-13

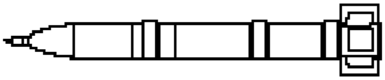


The S-13 is a large calibre unguided rocket (the 132-mm calibre) placed in the B-13 rocket pod (see figure above), each containing 5 rockets of this type. It is effective against fortified installations and hardened facilities (fixed emplacements, bunkers, hardened aircraft shelters, and runways). These unguided rockets can be fitted with warheads of various types. The concrete-piercing warhead can penetrate ground cover 3 metres thick or a vault of reinforced concrete of up to 1 m. The S-13 is launched at ranges up to 3000 metres.

The S-13T version of the rocket has a two-unit penetrating warhead detonating inside the target under attack after piercing its protective covering (a ground layer up to 6 metres thick or a reinforced concrete layer up to 2 metres). When the rocket hits a runway, it damages an area of about 20 square metres. The blast fragmentation warhead of the S-13OF version produces about

450 fragments weighing 25-35 grams each. Such fragments can pierce armour of light vehicles.

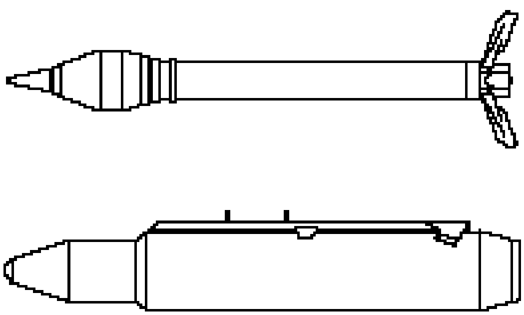
S-24



The S-24 is a large calibre (240-mm) unguided rocket fitted with a powerful solid fuel rocket motor. The motor operates for 1.1 seconds accelerating the rocket and providing stabilisation spinup. The S-24 rocket can be fitted with a blast fragmentation warhead containing 23.5 kg of high explosive. The body of the warhead is perforated and offers special induction hardening that provides very even fragmentation. After detonation, the body breaks up into 4000 fragments having an effective radius of 300-400 metres.

The rocket is usually fitted with a proximity fuse detonating over the target at an altitude of about 30 metres. To destroy hardened targets, the S-24 can have a delay-after-impact fuse. The warhead housed into a strong casing pierces the covering of the target and detonates inside. To launch the rocket, the pilot uses the APU-68 universal launch rail used for launching both guided missiles and unguided rockets.

S-25



The S-25 is a super-heavy unguided rocket housed in an expendable container (both the rocket and its container are shown in the figure). Inside its container, the rocket's four stabiliser fins are folded between four skewed jet nozzles providing stabilisation spinup.

There are several versions of the S-25 rocket in service. They differ in the warhead types used and are effective against various targets. The S-25-O fitted with a fragmentation warhead and a radio proximity fuse is effective against personnel, transport, parked aircraft, and other soft targets. The S-25-OF with a blast fragmentation warhead destroys lightly armoured vehicles, buildings, and personnel. The S-25-OFM has a modernised strengthened penetrating warhead, which is effective against hardened facilities and warehouses, shelters and other protected targets. The S-25 has an effective range of 2000 metres and a hit accuracy of about 0.3% of launch range.

The table below contains specification for various types of unguided rockets:

Type	Carrier (#)	Weight, kg	Warhead weight, kg	Warhead type
S-8B	MiG-27 (80), MiG-29 (80), Su-24 (120), Su-25 (160), Su-27 (120)	2.2	15.2	concrete-piercing
S-13OF/ S-13T	MiG-27 (20), MiG-29 (20), Su-24 (30), Su-25 (40), Su-27 (30)	2.5	68/67	blast-fragmentation/ penetrating
S-24B	MiG-27 (4), MiG-29 (4), Su-24 (4), Su-25 (8)	2	235	blast-fragmentation
S-25OF	Su-24 (6), Su-27 (6)	3	380	blast-fragmentation
S-25OFM	Su-24 (6), Su-27 (6)	3	480	penetrating

The GSh-301 Cannon

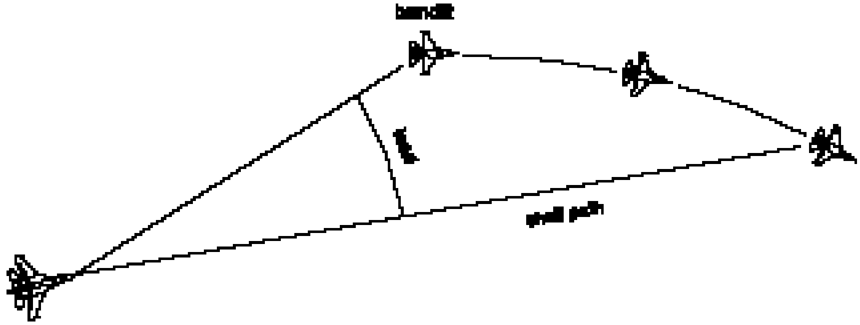
Many Russian combat aircraft, including the Su-27 and the MiG-29, are fitted with the GSh-301 30-mm cannon designed by the OKB led by V.P.Gryazev and A.G.Shipunov. The cannon is located in the starboard wing root extension and is normally used in conjunction with the laser rangefinder. The cannon is extremely accurate, having a fire rate of 1,500 rounds per minute, with 150 rounds of ammunition. The barrel of the GSh-301 has a 2,000-round life, equivalent to 80 seconds of fire at usual 1500 rpm. The cannon is fixed in the forward direction.

Strafing

During an attack on ground targets, the cannon and unguided rockets are employed in effectively the same way. The main differences are the maximum effective range and the minimum range (dictated by firing safety), which for GSh-301 are 1800 and 700 metres, respectively.

Air-to-air gunnery

Using the GSh-301 cannon against airborne targets is a relatively difficult task. Indeed, besides the gravitational descent of the trajectory of the shells, the pilot should consider the dynamics of relative motion of his aircraft and the target while the fired shells are travelling. All this boils down to finding the correct lead angle (see the figure on the next page).



Firing the GSh-301 cannon

The maximum effective range depends on the ballistic characteristics of the shells, geometry of aiming, speeds and altitudes of the aircraft and the target and many other factors. The minimum safety range mostly depends on the geometry of attack, closure rate and manoeuvrability of the shooting aircraft. Characteristic values of these ranges are 1000 and 200 metres, respectively.

Particular techniques of using the cannon in combat depend on the mode of fire being used. We will describe them in Chapters 5 and 6, devoted to air-to-air and air-to-ground combat, respectively.

Chapter 5.
Air Combat

The Su-27's primary mission is air superiority. Experience from WW II to the Persian Gulf war show that air superiority is a fundamental strategy of war both for the offensive and for the defensive parties. Though air superiority is just one of the many elements of modern warfare, it is fundamental to the success of tactical and strategic bombardment, air support of ground and navy forces and air reconnaissance.

Along with such tasks as fighter sweeps, raids on enemy airfields and so on, the Su-27 is well suited to defensive roles such as combat air patrol (CAP), interception and escort.

In this chapter we shall teach you how to destroy airborne targets. Remember, if the flight envelope of the Su-27 is still unknown to you then beware! You could become easy prey for a bloodthirsty adversary, who just can't wait for a sucker. Air combat tactics are beyond the scope of this book as they alone may come to quite a hefty volume.

Advances in the fields of electronics and missile technology have made it possible to engage in air combat beyond visual range. Numerous onboard systems (first of all, the radar and the electro-optical system) search and track targets and operate in common with the weapons control system to provide targeting for all the onboard weapons including the cannon. If these systems are damaged, you will only have the cannon at your disposal. Note that some types of infrared (IR) and active radar homing (ARH) missiles carried by the Su-27 allow you to lock onto a target using only the seeker head of the missile. It may come in handy if the radar and the electro-optical systems have failed.

Air-to-air Combat Modes

During ordinary flight, the radar and the electro-optical system (EOS) are unnecessary and the HUD and the MFD operate in Navigation Mode. As this takes place, the HUD Mode Indicator displays '**НАВ**' or a navigation submode notation such as '**МАРШ**', '**ПОС**', or '**НАВ**'. Once you've decided to get down to the business of searching for and destroying the enemy, then switch the onboard systems to combat mode. During an attack on an airborne target the pilot usually goes through the following steps: search, locate, identify, track and attack. He can accomplish these steps both with and without the radar and/or the EOS. The selection of one or other type of weapon mainly depends on the range to the target and the possibility of tracking the target using the onboard radar or the EOS.

Below are the principal flight/combat modes you can use while flying the Flanker.

Flight/combat mode	Russian designation	Key	Purpose
Navigation	**НАВ** ('nav')	1	Flight on instruments
Beyond Visual Range	**ДВБ** ('de-ve-be')	2	Acquire and hit airborne targets at long ranges (25 km to 150 km)

Flight/combat mode	Russian designation	Key	Purpose
Close Air Combat	**БВБ** ('be-ve-be')	3	Dogfight at ranges from visual to 25 km
Air-to-Ground	**ЗЕМЛЯ** ('zem-lja')	4	Acquire ground and water surface targets
Longitudinal Aiming	**ФИО** ('fee')	5	Aim using a missile's guidance system at ranges from visual up to max IR/active range of missile
Helmet	**ШЛЕМ** ('shlem')	6	Acquire agile target using helmet-mounted target designation system

Note. Before selecting any combat mode, you should make sure that the landing gear is up, otherwise you will not be able to change flight/combat mode.

The table below is a summary of the keys you will often use in combat. For information on the function buttons of your joystick turn to the Joystick Reference Card.

Key	Action
I	toggle radar
O	toggle EOS
~ (Tilde)	select next target (BVR Mode only)
Tab	lock on/off target
; (Semicolon)	move radar/EOS scan zone UP
, (Comma)	move radar/EOS scan zone LEFT
. (Dot)	move radar/EOS scan zone DOWN
/ (Slash)	move radar/EOS scan zone RIGHT
Ctrl+I	centre radar antenna/IRST ball
- (Minus)	MFD zoom in
+ (Plus)	MFD zoom out
CapsLock	cycle through weapons
C	enable/disable cannon
Ctrl+V	toggle Salvo mode
Ctrl+W	jettison weapons, step-by-step
Spacebar	fire current weapon
End	dispatch wingman on mission and allow him to return to base afterwards
Del	dispatch wingman on mission. On mission completion, join up
Home	join up
Ins	toggle tight formation/loose formation
[	attack my airborne target
]	cover my six

Acquiring Targets with Radar and EOS

The weapons control system (WCS) of the Su-27 is used to control missiles and bombs and comprises the following inter related components:

- the Zhuk-27 airborne radar;
- the 36-Sh Electro-Optical System (EOS);
- the system intended to control a particular type of airborne weapon (guided and unguided missiles, cannon, bombs);
- the data presentation system which includes the MFD and the HUD;
- the Parol (Password) Identification Friend or Foe (IFF) interrogator receiving signals from air and ground installations equipped with pertinent responders;
- the Helmet-Mounted Target Designator (HMTD).

We recommend using the onboard radar if you want to acquire aircraft at a relatively long range (up to 150 km with distance measurement) and take an advantageous position in good time before attacking the enemy. The only drawback is that the enemy can detect the illumination of your radar with relative ease. Furthermore, when you have locked onto an enemy target, its radar warning system indicates to the adversary that you are ready to attack him, and the adversary has time to prepare for its defence or counter-attack.

Zhuk-27 radar

The Phazotron Zhuk-27 (Beetle) coherent pulse-Doppler jam-proof radar is fitted with a twist cassegrain antenna of 700 mm in diameter and has the following features:

Air to air mode

- Look/down-shoot/down capability;
- Range-while-search;
- Track-while-scan of 10 targets;

Air to surface mode

- Real beam ground mapping;
- Doppler beam sharpening;
- Synthetic aperture;
- Map enlargement/freezing capability;
- Detection and tracking of moving ground targets;
- Air to surface ranging.

For targets with an effective scattering square (s) of 3 m2 (the MiG-29) the radar has a maximum detection range of 150 km (93 miles), and a maximum track range of 100 km (62 miles) in the forward hemisphere and 55 km (34 miles) in the rear hemisphere.

The radar transmits radio pulses of nearly equal frequency (within the X-band) and phase (coherent radiation). When the pulses are reflected from a moving target, the frequency changes (the Doppler effect). This allows you to acquire and track moving targets in ground clutter. The radar measures the range to the target using the information about the change of the signal phase in the reflected wave. This change is the result of a delay of the pulses propagating from the radar to the target and back to the radar. The closer the target, the less accurate is the measured range.

You toggle the radar by pressing the **I** key. The Radar Cue '**И**' (Russian 'I', stands for 'illumination') at the left of the HUD indicates that the radar is active. If the Radar Cue does not appear when you enable the radar, this means that latter is damaged. Note also that the radar and EOS can work simultaneously.

36-Sh electro-optical system

The radar is backed up by the 36-Sh electro-optical system (EOS) designed by the NPO Geophysica. The EOS can acquire thermally contrasting targets with heat signatures. It combines a laser rangefinder (effective tail-on range 8 km/5 miles) and Infra-Red Search and Track (IRST) system (effective range 50 km/31 miles). These use the same optics, which consist of a periscopic system of mirrors and an articulated glass sensor ball mounted centrally in front of the windscreen. The sensor ball moves in elevation (-10° down and +60° up for scanning, -15° down and +60° up for tracking) and in azimuth (60° and 120°, respectively). The information update rate depends on the field of view size and varies from 4 (search in wide area) to 0.05 (autotrack mode) seconds.

The EOS operates in passive mode by receiving IR emissions from the target and emits no signal. This allows the pilot to prepare a surprise attack on the enemy. Maximum detection range depends on the attack geometry. It changes from 15 km for forward-hemisphere attacks to 50 km for attacks in the rear hemisphere. The range to a target can be accurately measured only at relatively close distances (from 200 m to 3 km). You mainly use the EOS to provide targeting data for air-to-air missiles with an IR seeker head and for tracking targets in a guns fight.

To toggle the EOS, press the **O** key. The EOS Cue '**T**' (stands for 'Thermal' in Russian) at the left of the HUD indicates that the EOS is active.

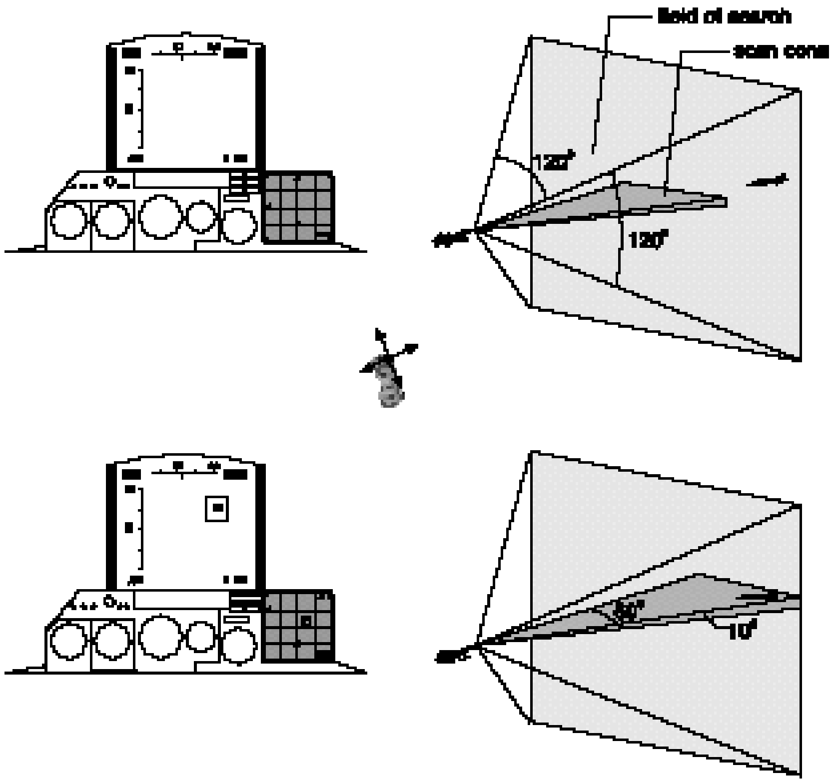
Note that the EOS and the radar can work together. This means that if the radar has lost the target the EOS will be tracking it on its own, and vice versa. If both the radar and the EOS are enabled you will see only the Radar Cue on the HUD. To clear up, you can switch off the radar: if the EOS Cue 'T' therewith appears that means the EOS is currently active. If the EOS Cue does not appear at all, this indicates that the EOS is either damaged or not correctly selected.

The EOS or missile's seeker can be slaved to the pilot's helmet-mounted target designator (HMTD) allowing the pilot to target simply by moving his head in the direction of the enemy aircraft. This is extremely convenient for acquiring agile targets at visual ranges.

Since the principles of using the radar and the EOS are practically the same, we describe these principles for the various combat modes in the same place, pointing distinctions as needed.

Beyond Visual Range Mode

In BVR Mode, both the radar and the EOS scan in a limited area - the scan cone, which has angular dimensions of 10° in the vertical plane (elevation scan angle) and 60° in the horizontal plane (azimuth scan angle). You can move the scan zone within the limits of an allowable field of search having angular dimensions of 120°x120° (see the figure below). Use the scan zone control keys or the coolie hat on your joystick.



In BVR Mode, the radar antenna is stabilised in roll and pitch. This means that the direction of the antenna axis does not change when the aircraft banks, pulls up or dives, providing that the aircraft manoeuvre doesn't exceed the gimbal limits of the antenna. Unlike in many Western aircraft, the beam shape of the Su-27's radar is fixed and cannot be changed. The maximum detection depends on the target's characteristics (geometry, aspect angle, radar reflectivity, etc.). Typically, the radar can detect a medium-size target such as a MiG-29 at a range of about 100-120 km. Large targets such as strategic bombers can be detected at distances up to 200 km.

Unlike the radar, the field of search of the electro-optical system is fixed to the aircraft and changes its orientation when you roll and pitch. The EOS can detect medium-size targets located no further than 50 km. Furthermore, the EOS cannot accurately measure the range to a target beyond approximately 15 km. Because of this, the HUD and MFD show approximate ranges to detected targets when using the EOS. That is why in BVR Mode the radar is used more frequently than the EOS.

When searching in a wide area both the radar and the EOS update target information at 4-second intervals.

Let us consider the sequence of steps, which you should perform to detect and acquire an airborne target with the radar or the EOS in the BVR combat mode.

Step 1. Make sure that the radar or the EOS is enabled and functional

The notation at the left of the HUD should read '**И**' or '**Т**', respectively.

Step 2. Switch to BVR Mode

Press the **2** key and check that the HUD Mode Indicator shows the notation of the BVR Mode ('**ДВБ**'). The radar or the EOS starts scanning in a cone of 10°x60° extending outward from the nose of your aircraft.

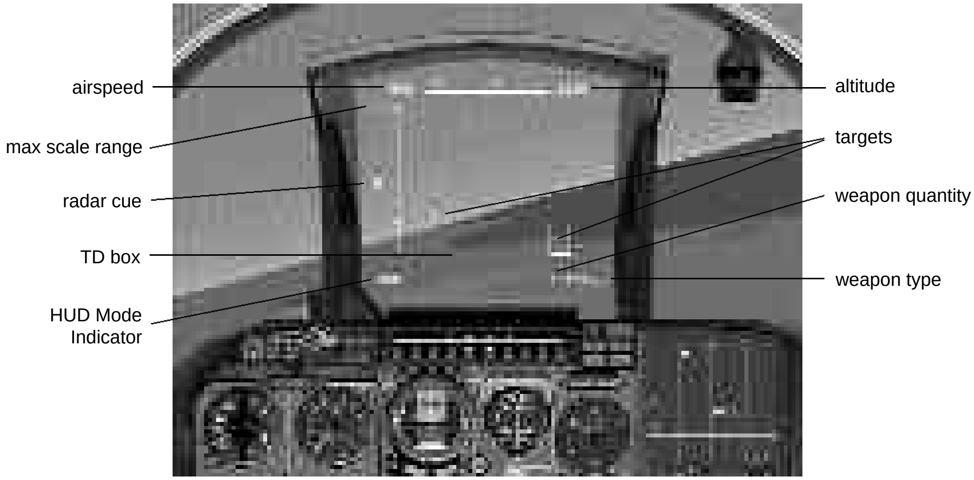
Step 3. Select a target

Using the coolie hat on your joystick or the scan zone control keys, aim the centre of the scan cone in the direction you want. The HUD and MFD immediately show information about detected targets, if any. To select a particular target, cycle through the targets with the tilde (**~**) key until the Target Designator Box (TD Box) appears on the desired target.

Step 4. Lock onto the target

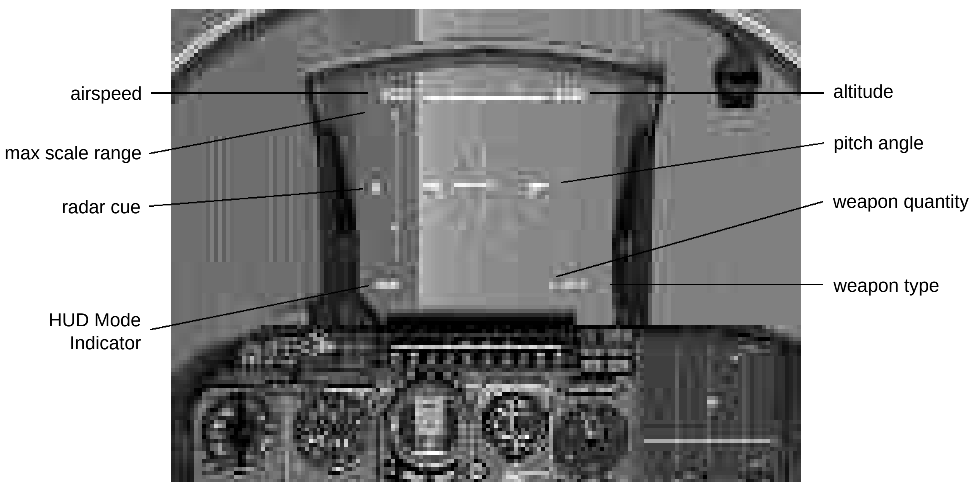
To lock onto the target, press **Tab**. If the locking conditions are met, the radar (the EOS) switches to Autotrack Mode as evidenced by the change of information on the HUD and MFD: if the target has been successfully locked, the Autotrack Cue 'A' appears above the Radar Cue or the EOS Cue. We'll describe Autotrack Mode in detail in a special section below. If you have failed to lock onto a target, the Autotrack Cue flashes at a frequency of 2 Hz. In this case you should repeatedly press **Tab** until the locking conditions are met and the Autotrack Cue turns permanent. We recommend locking onto a target at a range that is close to a reliable range of the selected AAM. It gives the target less warning that it has been locked on and your missile will have a chance of sneaking up on the target.

In BVR Mode all radar contacts appear on the HUD as points in an "azimuth angle — range" frame of reference located on the HUD. When using the EOS all contacts are displayed in an "azimuth angle — elevation angle" frame of reference. The locked target is additionally enclosed into a square - the Target Designator Box (see the figure below). The notations in the lower right corner of the HUD show information about type and quantity of the currently selected missile. The Weapon Readiness Panel illuminates the selected weapon with a yellow light.



Close Air Combat Mode

The Close Air Combat (CAC) Mode is used for attacking targets which you have spotted visually or which are known to be within close range (less than 25 km). The radar (the EOS) locks onto a target in an area limited by the angular dimensions of the HUD, namely 20°x20° (±10° in azimuth and ±10° in elevation). The EOS locks onto a target within 2-3 seconds.



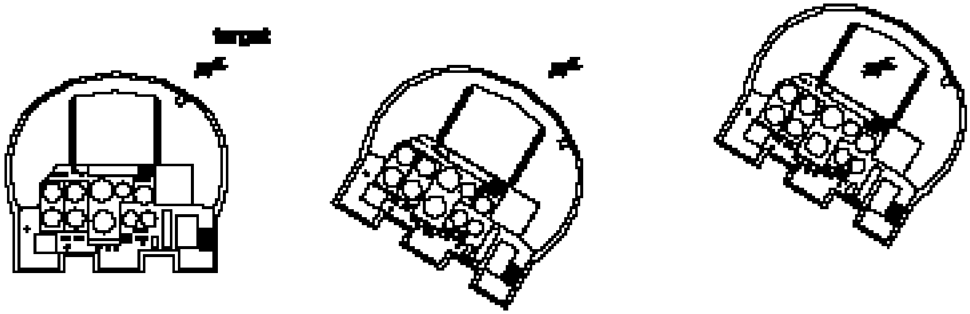
To acquire a target at close ranges, proceed as follows.

Step 1. Switch to CAC Mode

Press the 3 key and make sure that the HUD Mode Indicator shows the '**БВБ**' notation. Check the MFD for possible targets.

Step 2. Select a target

Once you have visually spotted a target, place it in the field of view of the HUD by manoeuvring your aircraft.



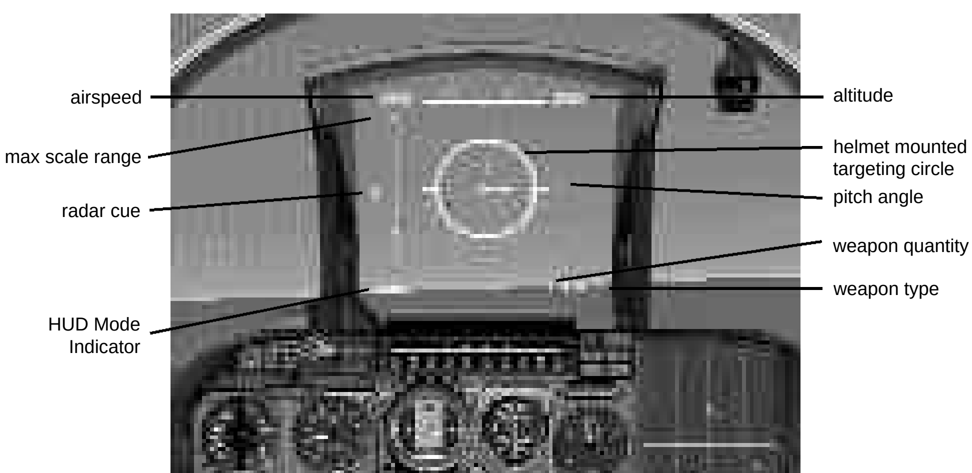
Step 3. Lock onto the target

To lock onto the target, press **Tab**. Failing locking conditions, the Autotrack Cue flashes at a frequency of 2 Hz. In this case press **Tab** until 'A' turns permanent. The radar (EOS) switches to Autotrack Mode as evidenced by the change of information on the HUD and MFD. If several targets are within the field of view of the HUD, the equipment tracks the target that has been detected earliest.

Helmet Mode

You use the helmet-mounted sight for attacking a visible airborne target in a dogfight. This Helmet-Mounted Target Designation (HMTD) system NSTs-27 frees the pilot from having to boresight his enemy by slaving the radar or the EOS (or even the missile seeker) to the helmet-mounted sight. The Helmet Mode (also called the Track View) lets you to keep your eye on the target at all times by turning your head in the direction of the target’s motion. The real system works by using a pair of head position sensors on the panel, on each side of the HUD.

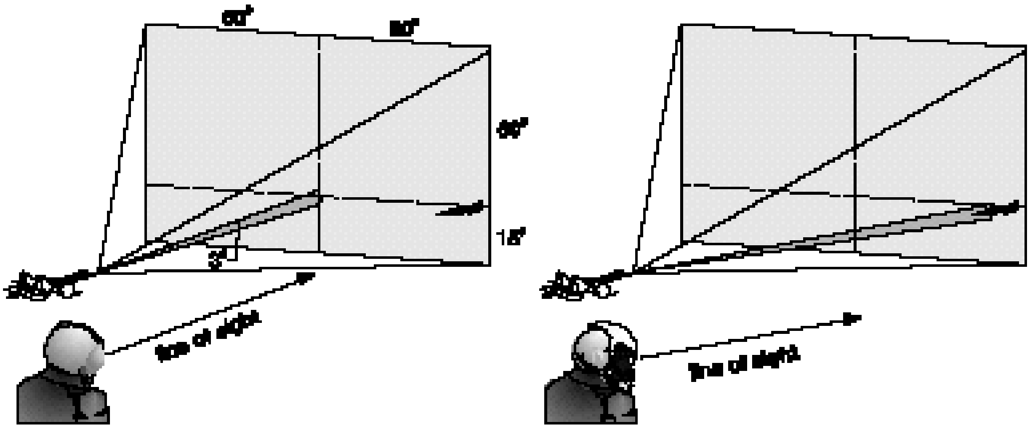
The radar (the EOS) locks onto the target in an area limited by the scan cone, which angular dimensions in Helmet Mode are about 3°x3°. The pilot should keep the cone in the limits of the radar (EOS) field of search. That means that you cannot use your helmet-mounted sight to acquire and lock onto targets beyond the gimbal limits of the radar antenna, the IRST sensor ball or missile seeker (whichever system is slaved at the time).



Step 1. Switch to Helmet Mode

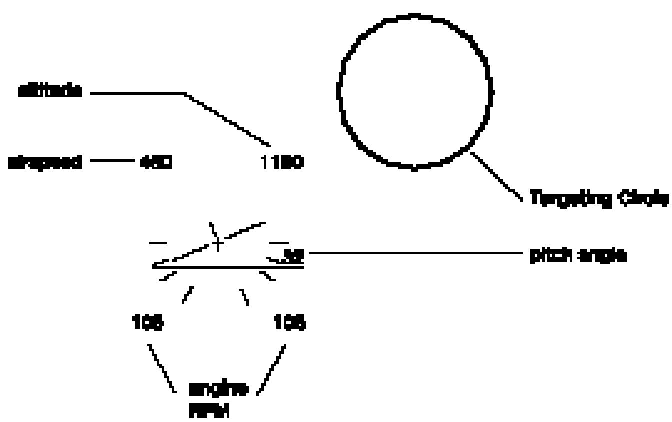
To do this, press the 6 key. The HUD Mode Indicator displays the notation '**ШЛЕМ**' (pronounced 'shlem', denotes 'HELMET' in Russian). The Targeting Circle appears in front of you and follows the movement of your head. The MFD gets information corresponding to close air combat.

Step 2. Select a target



Once you have visually spotted a target, place it within the Targeting Circle by manoeuvring the aircraft and turning your head in the direction of the target. You can move your head using the joystick coolie hat or the numeric keys on the keypad. In so doing, the Targeting Circle moves with your head. The figure above illustrates how you search for a target when the EOS is slaved to the HMTD system. To padlock your HMTD onto the target, press **Grey_*** on the keypad.

If the HUD gets out of view, a set of visual cues appears next to the Targeting Circle. These cues indicate your airspeed and altitude, the aircraft datum and pitch angle, and the engines RPMs (105% for both engines in the figure below).



Step 3. Lock onto the target.

To lock onto the target, press Tab. The radar (EOS) switches to Autotrack Mode.

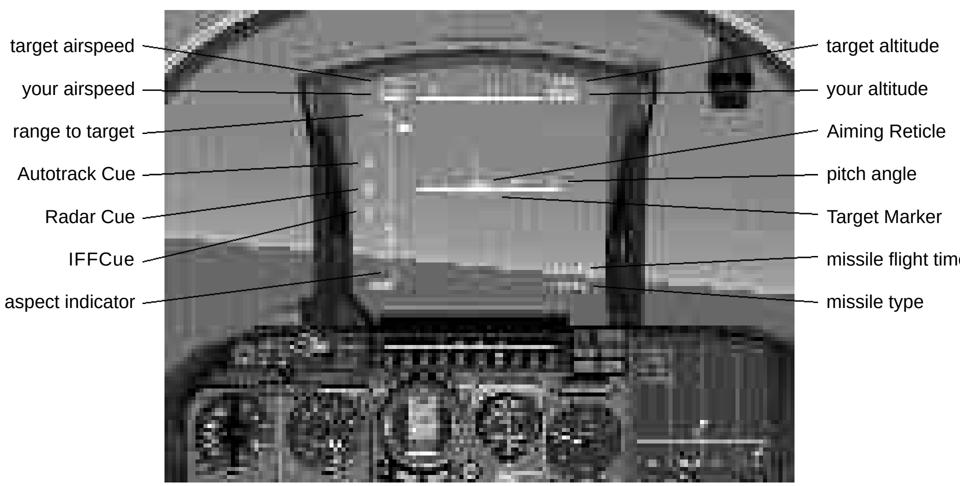
Autotrack Mode

After locking onto a target in BVR, CAC or Helmet Mode, the radar (EOS) switches to Autotrack Mode that lets you automatically track a single target. In this mode the radar antenna (or the optic sensor ball of the EOS) is steadily directed to the locked target.

Radar tracking area for a single target is about 120°x120° in elevation and in azimuth, and tracking range for a medium-size target is from 55 km (rear hemisphere) to 100 km (forward hemisphere). When operating in Autotrack Mode, the radar provides target designation for guided missiles and illuminates targets for missiles fitted with SARH seekers.

If you use the EOS, the tracking area coincides with its field of search and equals 75° in elevation (15° down, 60° up) and 120° in azimuth. Tracking range depends on the type of target and the attack hemisphere. The EOS measures distances to the target for ranges from 0.2 to 3 km, with an accuracy of 10 metres. When operating in Autotrack Mode, the EOS provides target designation for guided missiles fitted with an IR seeker head.

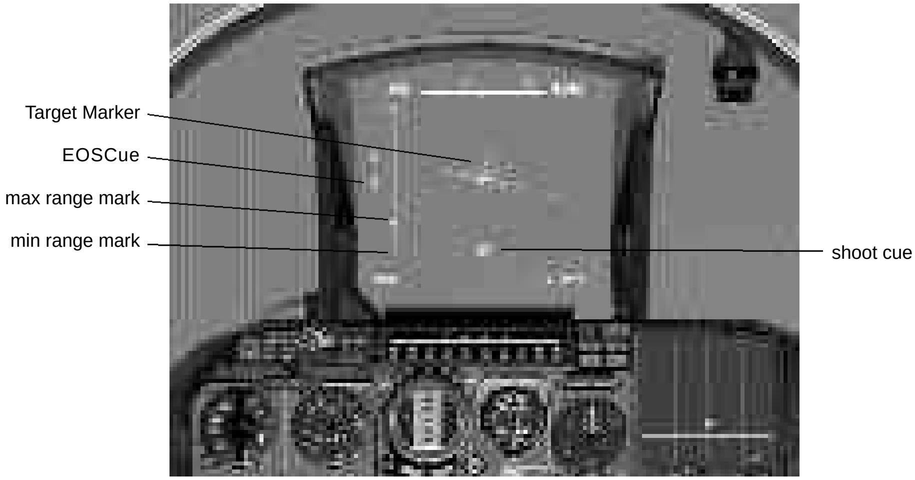
After the radar (EOS) has locked onto the target, the HUD shows the following information: the 'A' Autotrack Cue, the range scale with the minimum and maximum launch range marks, the range to target mark (radar only), and the target aspect angle arrow. The HUD also displays the Aiming Reticle, altitudes and true airspeeds of your aircraft and of the target, the aircraft datum and bank scale, current combat mode, type of missile, quantity of the missiles, and missile flight time. The target's position is shown on the HUD as a point (the Target Marker) in angular coordinates scaled to the dimensions of the tracking area (see the figure below).



Typical HUD symbology for autotracking with the radar

Green lights on the Weapon Readiness Panel indicate that the missiles are ready for launch. The MFD works in track mode displaying information about the target. When you are tracking the target using the radar, target information may disappear for some time if the target deploys ECM or decoy countermeasures.

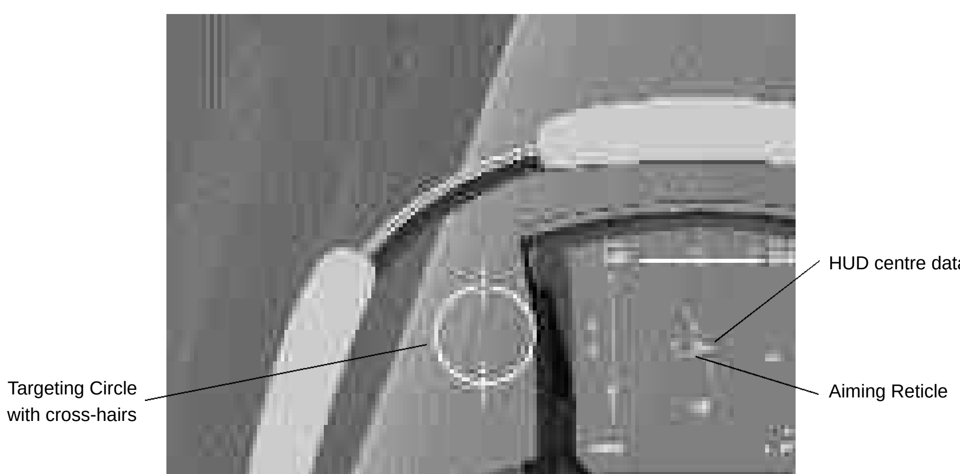
When you use the EOS, the HUD shows range, aspect angle, true airspeed and altitude of the target, and missile flight time only if the rangefinder can measure range (less than 3 km). If the range to the target cannot be measured, the position of the target marker will be shown approximately. Here, you do not have information about type of target and the parameters of the target's motion (see the figure below).



Typical HUD symbology for autotracking with the EOS

The HUD will also display the '**ПР**' Shoot Cue or '**OTB**' (pronounced 'o-te-ve', stands for 'TURN AWAY' in Russian) Reject Cue. The Shoot Cue informs you that the selected missile is ready for launching and the target is within the missile's reliable launch parameters. Fire the missile by pulling the trigger (**Spacebar**). The Reject Cue warns that you are too close to the target and prohibits launch. If you lock onto friendly aircraft, the IFF (Identification Friend or Foe) Cue at the left of the HUD will show '**C**' (stands for the Russian word '**Свой**' and denotes 'Ours').

If the radar or the EOS switches to autotracking from Helmet Mode, cross-hairs superimpose on the Targeting Circle (see the figure below). When the HUD gets the Shoot Cue, the Targeting Circle flashes at a frequency of 2 Hz. If the onboard computer does not get target range information, the Targeting Circle flashes with a frequency of 1 Hz (this is typical when using the EOS).



When tracking a target in Autotrack Mode, manoeuvre your aircraft so that the Aiming Reticle stays close to the HUD centre datum. This eases your work load when the target is not very visible and prevents the target from breaking the lock. Remember, if you use the EOS, the flashing of the Shoot Cue with a frequency of 1 Hz warns you that the system is not measuring the range to the target.

Keep in mind that for SARH missiles, it is necessary to illuminate the target for the entire flight time of the missile. So know your missiles!

If the target leaves the tracking area, or you break the lock by pressing the Tab key, or the target is destroyed, the radar (the EOS) returns to the mode which immediately preceded the Autotrack Mode. If the radar or EOS is damaged or you switch transmission off, the lock breaks and the radar returns to BVR, CAC, or Helmet Mode.

Direct Targeting with the Missile Seeker

Should the radar or the EOS be damaged, you can still use the direct targeting capability of missiles fitted with IR or active radar seeker heads. This requires placing the target into the seeker's field of vision and locking on. The seeker tracks the target in an area limited by its gimbal limits and by the tracking range. The latter depends on the type of missile, type of target, and attack geometry.

For direct missile targeting the Flanker pilot can employ the following modes:

- *longitudinal missile aiming* ('**ФИО**')
- *helmet-mounted target designation* ('**ШЛЕМ**')

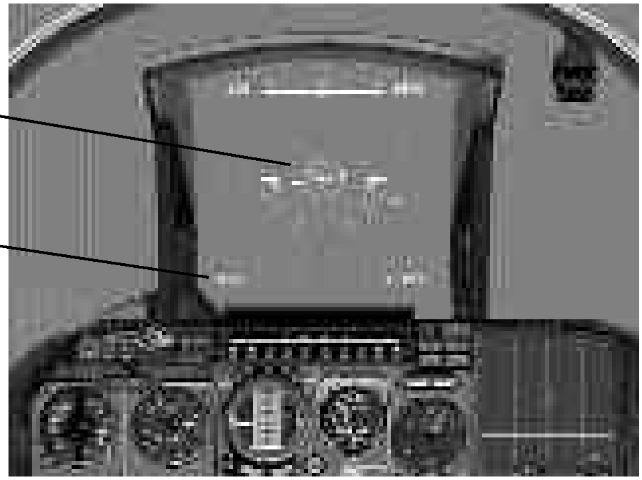
Longitudinal Missile Aiming

You use the LMA Mode for attacking a visible airborne target in a dogfight. The missile seeker locks onto the target in an area limited by the angular dimensions of the seeker's field of vision (about 3°), which is aligned along the longitudinal axis of the aircraft. The seeker head locks onto the target within 2-3 seconds.

To lock onto a target in LMA Mode, you should accomplish the following steps:

Step 1. Switch to Longitudinal Missile Aiming Mode

To do this, press the 5 key. If the selected missile has a seeker head of an appropriate type, the HUD shows the fixed Aiming Reticle (3°) and the seeker aligns itself along the longitudinal axis of the aircraft. The Weapon Readiness Panel shows the selected missiles. The MFD displays information corresponding to CAC Mode.



Step 2. Select a target

Once you have visually spotted a target, place it within the Aiming Reticle by manoeuvring your aircraft.

Step 3. Lock onto the target

Enter targeting data into the seeker head by pressing the Tab key. If the locking conditions are met, the seeker locks onto the target and starts tracking it. We'll describe the Seeker Track Mode in a separate section below.

Helmet-mounted target designation

You can use Helmet Mode ('**ШЛЕМ**') for direct targeting of a missile seeker head without any aid from the radar or the EOS. In this mode the seeker's field of view can change its orientation following the movement of your head. A target can be locked as soon as the seeker sees it. Angular movements of the seeker's field of view are limited only by the gimbal limits of the seeker head.

Step 1. Switch to Helmet Mode

To do this, press the 6 key. Note that the radar and the EOS are disabled. The HUD Mode Indicator shows the notation of the given mode, that is, '**ШЛЕМ**'. Besides that, the HUD displays the Targeting Circle, which follows the movement of your head. The Weapon Readiness Panel illuminates the selected missile. You should pay special attention to the type of selected missile and its seeker head, as the Targeting Circle appears on the HUD whatever the type of selected weapon.

Step 2. Select a target

Once you have visually spotted a target, place it within the Targeting Circle by manoeuvring the aircraft and turning your head in the direction of the target. The seeker head will follow the movement of your head, up to its gimbal limit. Padlock your HMTD onto the target by pressing Grey_* on the keypad.

Step 3. Lock onto the target

If locking conditions are met, the seeker head can lock onto the target. Enter targeting data into the seeker by pressing the **Tab** key. Locking is acknowledged by the information change on the HUD and appearance of cross-hairs on the Targeting Circle.

Seeker Track Mode

After a missile seeker has locked onto the target, it switches to track mode continuously keeping the target within the seeker's field of view. The dimensions of the single target tracking area depend on the type of missile and are limited by the gimbal limits of the seeker head. Gimbal limits may range from 20° (the R-60 Aphid) to 80° (the R-77 Adder). Tracking range depends on type of target and specifications of the seeker head and may vary between 5 km and 15-20 km.

When the seeker tracks a target the HUD shows the following information: altitude and true airspeed of your aircraft, aircraft datum and bank scale, type of missile and quantity. The HUD Mode Indicator displays either '**ФИО**' or '**ШЛЕМ**', depending on the previous mode. Lock onto the target is evidenced by the movable Aiming Reticle showing an angular position of the seeker head and by the Shoot Cue '**ПР**' flashing with a frequency of 1 Hz. If the seeker head locks onto the target from Helmet Mode, the Targeting Circle flashes with a frequency of 2 Hz. Simultaneous flashing of the Shoot Cue and the Targeting Circle indicates the lack of target range information.

You should manoeuvre the aircraft so that the movable Aiming Reticle stays close to the HUD centre datum. This eases aiming at the target and prevents the target from breaking the lock.

If the target leaves the tracking area of the seeker head, or you break the lock by pressing Tab, or the target is destroyed, the HUD returns to the mode which immediately preceded the track mode ('**ФИО**' or "**ШЛЕМ**').

Using the GSh-301 Cannon

When the WCS operates in air-to-air combat mode (BVR, CAC, LMA, or Helmet), you can enable your GSh-301 cannon at any time by pressing the **C** key. Depending on whether or not the radar (EOS) has been locked onto the target, the gunnery with the cannon can be performed:

- with targeting from the radar or the EOS
- without assistance from the radar or the EOS.

Firing the cannon with targeting from the radar or EOS

In comparison with employing missiles, the parameters of relative motion of your aircraft and the target are of even greater importance for successful use of the cannon because you should hit the manoeuvring target with unguided shells.

If you want the radar or the EOS to assist when firing the GSh-301, lock onto the target before selecting the cannon.

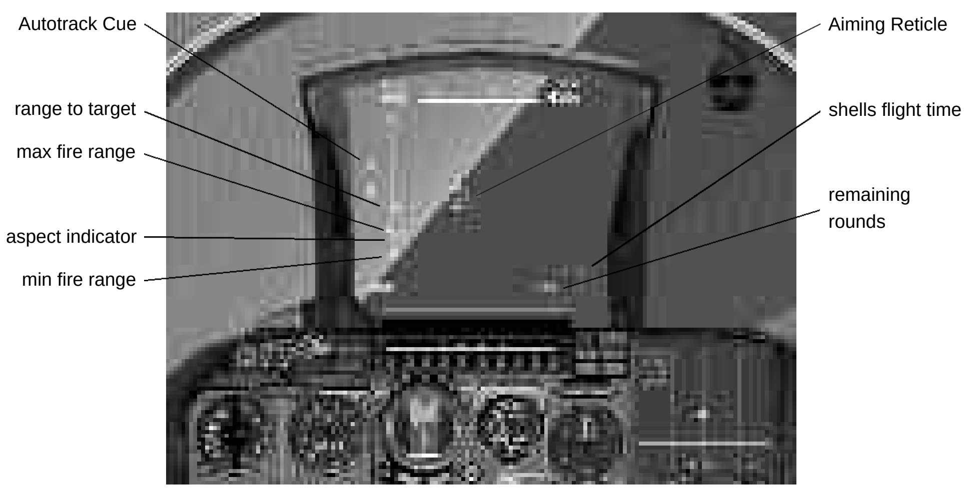
Long range (> 1400 metres)

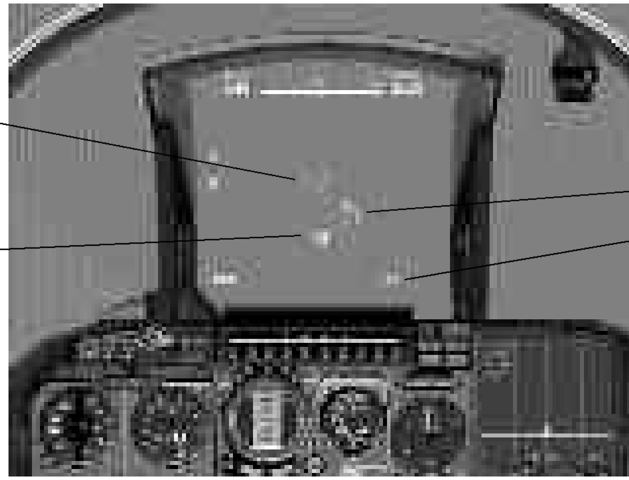
When the locked target is at a long range from your aircraft, the HUD shows the following information: the Autotrack Cue on the left, next to the range scale with the minimum and maximum range marks and range to target arrow. At the bottom of the scale there is the target aspect arrow. The Aiming Reticle tracks the target. At the lower right there are two numbers: remaining rounds for your cannon and shells flight time.

You should manoeuvre the aircraft so that the Aiming Reticle stays close to the centre of the HUD. This prevents the target from breaking the lock. When the aircraft has closed in on the target to a range of 1400 metres, the HUD symbology changes to close range targeting.

Close range

When the locked target is at a range of less than 1400 metres from your aircraft, the HUD shows the following information: the Autotrack Cue at the left and the Aiming Reticle surrounding the target. The range scale in this HUD mode is not present: the movable Gun Pipper with a circular range scale and cross-hairs appears near the centre. The circular range scale may change from the full circle, which corresponds to a range of 1400 metres, to an arc indicating the range to the target. The smaller the arc, the closer the target. The remaining rounds are also displayed at the lower right. The figure below shows the close range symbology.





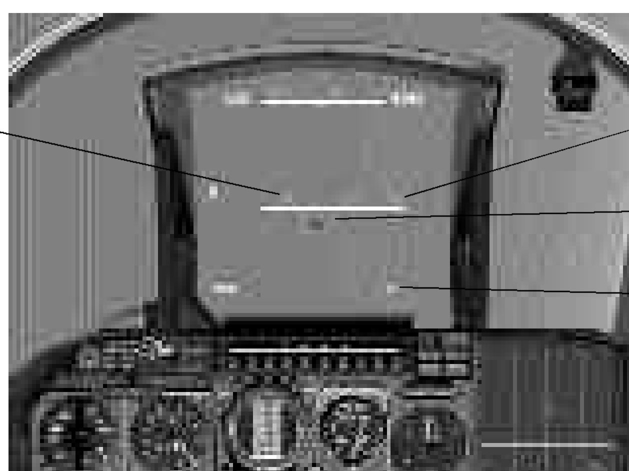
You should manoeuvre your aircraft so that the Gun Pipper superimposes onto the Aiming Reticle. When the Gun Pipper is placed on the Aiming Reticle, the optimal conditions for lead angle are met, and the HUD shows the Shoot Cue testifying that the target is within an effective shooting range. If you approach the target too close, the HUD may show the Reject Cue '**OTB**'.

The target lock may break as a result of your incorrect actions or manoeuvring of the enemy aircraft. If this happens, then the HUD symbology changes to that for the cannon without targeting from the radar or the EOS: the Aiming Reticle and the Gun Pipper are replaced by the Funnel (see description below). If you want to autotrack the target again, disable the cannon (press **C**) and try to lock the target with the radar of the EOS.

Using the cannon without targeting from the radar or EOS

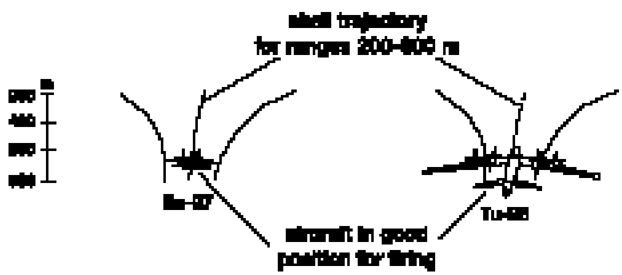
You can fire the GSh-301 cannon without targeting from the radar or the EOS. In this case the Weapons Control System computes shell trajectories for several ranges with consideration for the movement of your aircraft.

In this mode the HUD shows the "Funnel" symbology: two curves corresponding to the projections of the left and right wings of the imaginary target with regard to range and shell trajectory.



The Funnel allows you to estimate the range to the target from the target's angular dimensions and the interval between the curves. The wingspan of the imaginary target is assumed to be 15 metres (approximate wingspan of the Su-27 and F-15). Manoeuvre until the target comes between the Funnel curves with due regard to its wingspan of the real target and the imaginary target projection curves. Hence an aircraft with a much bigger wingspan (such as the Tu-95) should overlap by a certain degree the Funnel curves in order to be within the shell trajectory.

To estimate range to the target, you can use the following figure. When an aircraft is positioned within the Funnel with respect to its wingspan, the top of the Funnel corresponds to a range of 200 metres while the bottleneck, to 800 metres. In the figure, both aircraft are at a range of some 700 m and in a proper position for firing.



As gravity acts upon shells, the firing trajectory slopes downwards.

Below is a reference table of wingspans of the aircraft you can find in the Flanker simulation. For aircraft with variable-sweep wings the table shows two values, namely, the minimum and maximum wingspans.

Aircraft	Wingspan, m	Aircraft	Wingspan, m
MiG-23	7.8/14	Tu-22	23.6
MiG-27	7.8/14	Tu-95	50.05
MiG-29	11.36	Tu-142	51.1
MiG-31	13.46	Il-76	50.3
Su-24	10.36/17.63	A-50	50.3
Su-25	14.36	F-15	13.1
Su-27	14.72	F-16	9.4

Chapter 6. Hitting Ground Targets

Hitting ground and water surface targets is more characteristic of bombers and strike aircraft. However, the Su-27 can carry a wide variety of bombs (from free-fall to high-drag bombs), air-to-ground missiles and unguided rockets.

Ground target work may be conventionally divided into the following steps: search, identify, and attack. If a target you are searching for cannot be spotted visually, use your radar, which helps to acquire targets at long ranges and where appropriate download the target coordinates into the Weapons Control System (WCS). The appropriate aircraft bomb and missile payload depends very much on the type of mission planned and expected targets. In this chapter we shall teach you how to search for ground/water surface targets and how to use the following weapons:

- General-purpose tactical missiles;
- Antiradar missiles;
- Antiship missiles;
- Unguided rockets and the GSh-301 cannon;
- Unguided bombs;
- Guided bombs.

To switch the onboard systems to Air-to-Ground (A2G) Mode, you should press the 4 key and check that the HUD Mode Indicator reads '**ЗЕМЛЯ**' (Russian designation for GROUND, pronounced 'zem-lja').

To control your weapons and onboard systems in A2G Mode, you use the same keys as in the air-to-air modes:

Key	Action
I	toggle radar
O	toggle EOS
~ (Tilde)	select next target (BVR Mode only)
Tab	lock on/off target
; (Semicolon)	move radar/EOS scan zone UP
, (Comma)	move radar/EOS scan zone LEFT
. (Dot)	move radar/EOS scan zone DOWN
/ (Slash)	move radar/EOS scan zone RIGHT
Ctrl+I	centre radar antenna/IRST ball

Key	Action
- (Minus)	MFD zoom in
+	MFD zoom out
CapsLock	cycle through weapons
C	enable/disable cannon
Ctrl+V	toggle Salvo mode
Ctrl+W	jettison all weapons
Spacebar	Fire current weapon

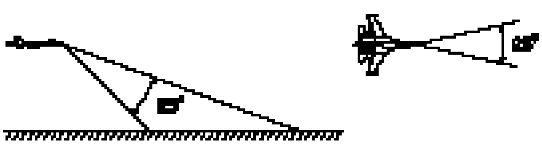
Note that selecting the cannon temporarily disables all other weapons carried by your jet.

Searching for Ground Targets with Radar

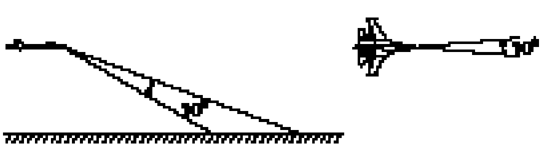
In A2G Mode the Zhuk-27 radar scans ground surface within the limits of its field of search of angular dimensions of 120°x120° in a range of 3-150 km. The maximum size of the scan zone along the flight path is limited both by the maximum deflection angle of the radar antenna (60°) and by its inclination angle with respect to the horizon (3°). Linear dimensions of the field of search depend on your altitude - the higher you fly, the bigger the dimensions of the field of search. Surface scan time lies in the range between 3 and 15 seconds and depends on the size of the area swept by the radar.

You can use the radar for searching for ground targets and designating targets in the following modes differing in the size of the scan area, resolution, and scan time:

1. *Scan Mode* provides for coarse mapping of the terrain laying dead ahead;

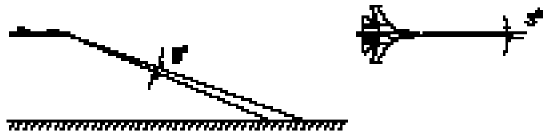


2. *Search in Wide Area:* surface mapping in the Doppler beam sharpening mode. In this mode the system displays a map with magnification by 20.



3. Search in Narrow Area: this operational mode uses a map magnified by 64 times and allows the pilot to locate targets in a relatively small area. In this mode the WCS calculated the co-ordinates of the designated ground or water surface target. The WCS uses this information to enter targeting data for anti-ship missiles. It can also help you deliver other types of air-to-

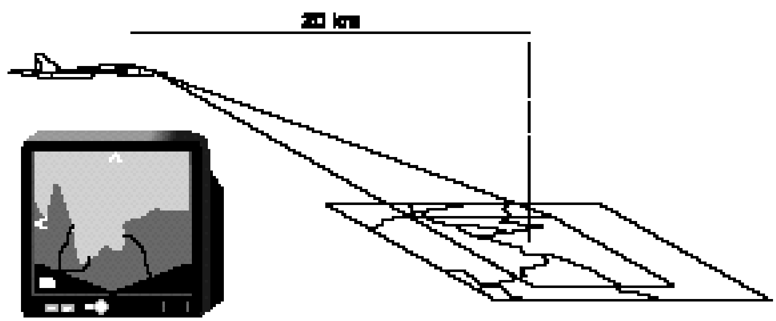
ground weapons such as tactical missiles, bombs and unguided rockets by providing a special radar target designator on the HUD.



When you switch the radar in A2G Mode (the **I** key), the '**И**' Radar Cue and the Radar Target Designator in the shape of a diamond appear on the HUD, and the radar starts operating in Scan Mode.

Scan Mode

In the Scan Mode the radar scans the terrain ahead in a cone with angular dimensions of 25°x25°. You can control how far your radar looks at the ground by orienting the radar antenna (the scan cone) in the vertical plane, that is, by changing the inclination angle of the antenna with respect to the horizon. The scan cone is stabilised in roll and pitch, in other words, the direction of the antenna axis with respect to the horizon will not change when you roll or pitch. However as your heading changes, the scan zone moves so that its centre is always lined up with the aircraft's longitudinal axis.



The MFD processes radar information into a synthesised image of the terrain as if you were looking at the ground map from above. Two dark areas at the bottom of the MFD represent blind areas of the radar, since its scan zone is limited by 120° in azimuth. Two V-shaped indexes, one to the left and another at the top of the MFD, show the position of the scan zone centre with respect to the aircraft's longitudinal axis. Distance to the centre of the scan zone in kilometres is shown in the lower left-hand corner of the MFD. You can move the scan zone centre farther or nearer with the coolie hat on your joystick or with the scan zone control keys. To move the scan zone left or right, you should change the heading.

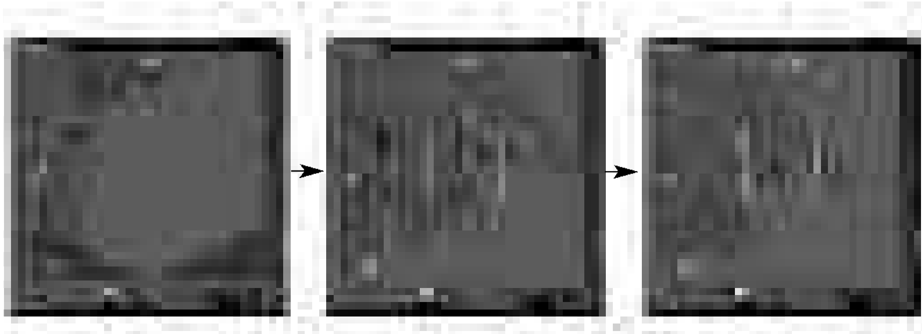
The diamond-shaped Radar Target Designator shows on the HUD the direction of the scan zone centre. If the Radar Target Designator goes beyond the limits of the HUD, the diamond is overlapped by the 'X' symbol and stays near the edge of the HUD. To return the Radar Target Designator to normal state, you should manoeuvre the aircraft correspondingly or choose a new direction of the scan zone with the control keys or the coolie hat.

After you have selected an area of interest using information shown on the MFD, you can narrow you search by switching the radar to Search in Wide Area (SWA) Mode. To do this, press the **Plus** key.

Search In Wide Area

In the SWA Mode the radar scan zone has angular dimensions of about 10°x10° and moves with the aircraft, i.e. is not stabilised as in the Scan Mode. This means that if you pitch up the nose the radar will be looking farther, and vice versa.

Information on the HUD is similar to that of the Scan Mode. The MFD shows an enlarged synthesised image of the terrain with the Narrow Search Area (NSA) frame in the centre. Again, the number in the lower left-hand corner of the MFD shows distance to the centre of the scan zone that is to the centre of the NSA frame.



You can control the position of the scan zone centre as to angles in vertical and horizontal planes with the coolie hat or with the scan zone control keys. Once you have placed the NSA frame on your desired search area, switch the radar to Search in Narrow Area (SNA) Mode by pressing the **Plus** key again. This will allow you to get a detailed image of the terrain on the MFD and select individual objects for tracking. If you change you mind and want to return to Scan Mode, press the **Minus** key. In so doing, the position of the radar antenna will not change.

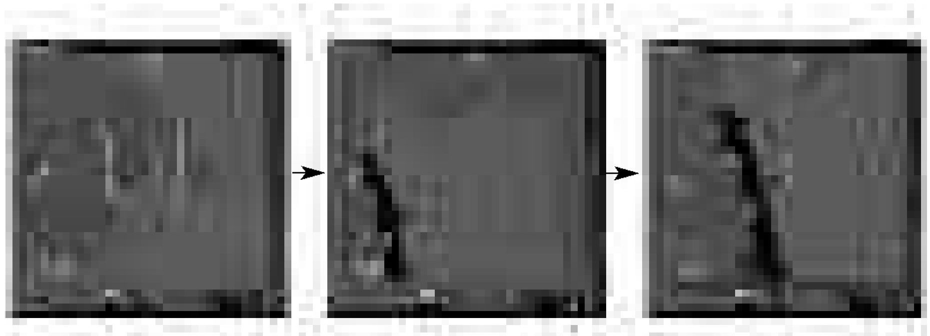
Search In Narrow Area

In the SNA Mode the angular dimensions of the scan zone are equal to 3°x3°, which provides maximum magnification in the selected area. You control the scan zone in much the same way as in SWA Mode, however, the scan zone centre does not move with movements of the aircraft, since the radar tracks a certain point on the ground or water surface.

The SNA Mode refers the position of your aircraft to the position of the selected point on the ground. Even if the line of sight to the selected point moves beyond the field of search, the radar will resume tracking that point as soon as this becomes possible. Locking on a point provides accurate target designation for anti-ship missiles and facilitates sighting for other types of ASMs, bombs and unguided rockets in conditions of poor visibility or at night.

The MFD shows a synthesised image of the terrain with cross-hairs in the centre of the search area. Using information on the MFD, you select a target (building, bridge, vehicle, etc.) by placing the cross-hairs on the target with the coolie hat or the scan zone control keys. You can also target visually by superimposing the Radar Target Designator on a target of interest. Thus, the diamond in the SNA Mode always points to the designated target.

Note that you cannot just designate any point on the ground or water surface: the radar is capable of tracking only a certain 3D object, which can be distinguished from background. Otherwise, the track error would increase since the onboard computer cannot integrate the movement of the aircraft with respect to coordinates of a certain point with absolute accuracy. This could result in the calculation of wrong coordinates.



Once you have placed the cross-hairs on the target, its position becomes known to the WCS. If you've selected an anti-ship missile, switch the radar to Autotrack Mode by pressing the **Tab** key (for more information on the Autotrack Mode read the section below devoted to anti-ship missiles). For other weapons you normally start flying in the direction of the Radar Target Designator to close in at a distance which enables accurate targeting and striking with the selected weapon.

If you change your mind and decide to search for another target, move the cross-hairs on the HUD to a new location or switch back to Scan Mode by pressing Plus or Minus.

Striking Targets

The methods of using air-to-ground weapons greatly depend on their type. However, there are some common ways of interpreting the commands of the Weapons Control System and using weapons against ground or water surface targets:

1. Make sure that the Weapons Control System and the HUD are in the A2G Mode as shown by the '**ЗЕМЛЯ**' designation on the HUD Mode Indicator (if not, press **4**).

2. Choose optimal weapons for the planned target by cycling through onboard weapons (press the **CapsLock** key). To toggle the cannon, hit the **C** key. The selected type of weapon and its remaining quantity will be shown at the lower right-hand corner of the HUD. The Weapon Readiness Panel illuminates the pylons carrying the selected weapon.

3. Place the Aiming Reticle on the visual target or the cross-hairs on the target's image on the MFD by manoeuvring your aircraft.

4. After you place the target in the sight, lock onto it to provide targeting information for the selected weapon or just fire (depending on the weapon used).

5. Select Salvo mode if you want to fire unguided rockets from all available pods or release all bombs simultaneously. To toggle Salvo mode, use the **Ctrl+V** keys. If this mode is active the weapons type and quantity symbology on the HUD are enclosed in a rectangle.
6. If the selected weapon requires that specific conditions for range or other parameters should be met, you have to wait until the '**ПР**' Shoot Cue appears on the HUD and only then start firing.

Using tactical missiles

The principle general-purpose tactical missiles for the Su-27 is the Kh-29 (AS-10 'Karen') which is effective against fortifications, major railway and highway bridges, launchers, ships, surfaced submarines, etc.

When you have selected a tactical missile, the MFD gets information either from the missile seeker or from the radar if the latter has been enabled. In this mode the HUD displays the Aiming Reticle representing the angular position and the field of view of the missile seeker. You can move the field of view by using the coolie hat or the scan zone control keys. In so doing, the Aiming Reticle on the HUD and the cross-hairs on the MFD move. After closing in on the target, you should switch off illumination if it has been enabled and perform accurate aiming using information fed to the MFD by the missile seeker head.

If the missile is fitted with a TV or IR seeker (in this simulation we use both versions of the Kh-29) the MFD displays an enlarged terrain image (TV or thermal) and shows the aiming cross-hairs. By manoeuvring your aircraft and/or the missile's seeker head with the coolie hat or scan zone keys, place the target into the seeker's field of vision (represented by the Aiming Reticle on the HUD) and superimpose the cross-hairs on the target shown on the MFD (see the figure below).

Then you should press **Tab** to designate the target for the missile. If the locked target is not your primary target, cancel the lock by pressing **Tab** again and continue searching for a new target.

Locking onto a target is accompanied by the WCS switching to Lock-on Mode. The lock is evidenced by the change of information on instruments: the Aiming Reticle starts tracking the target across the HUD, the target's image on the MFD stops moving and becomes surrounded by a square lock frame, and the missile's flight time appears in the lower right-hand corner of the HUD.

Within a few seconds the Weapon Readiness Panel illuminates the selected missile with a green light showing its launch readiness.

In Lock-on Mode the Aiming Reticle represents the angular position of the seeker head. You should manoeuvre the aircraft so that the Aiming Reticle stays close to the centre of the HUD - this prevents the target from breaking the lock.

Once within launch range (the target range marker q falls between the maximum and minimum launch range marks), the HUD shows the '**ПР**' Shoot Cue. Fire! (pull the trigger or press **SpaceBar**). After the missile has left the pylon, the WCS changes back to the mode that preceded the Lock ON Mode.

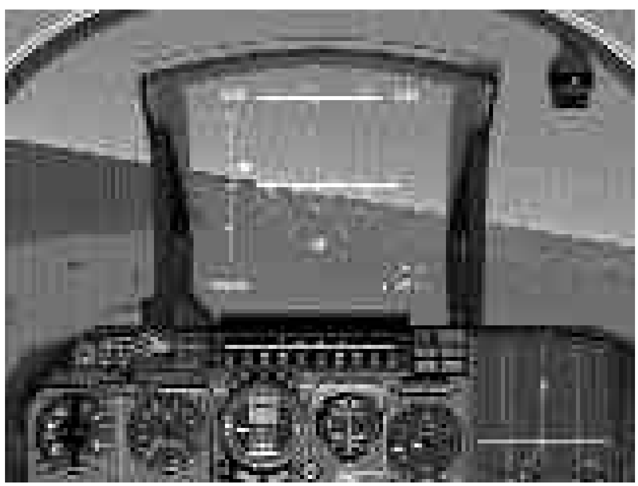
If distance to the target is less than the minimum launch range, the WCS outputs the '**OTB**' Reject Cue and disables the launch.

Using antiradar missiles

An antiradar missile, for example, the Kh-31P (AS-12 'Kegler') can strike radio illumination sources such as various air defence radar (ground-based or shipborne), air traffic control radar and early warning radar. You normally detect enemy radar using warnings from the SPO-15 Radar Warning System, which outputs the information to the Threat Warning Display (TWD) and attracts your attention with audible beeps and flashing of the Master Warning Indicator. The TWD periodically flashes an amber light showing an approximate direction to the threat.

Once enemy radar has swept over your aircraft, switch off your onboard radar if it has been enabled (press **I**), and select an antiradar missile. The MFD will show a radar symbol for the detected enemy radar. For an antiradar missile, the Aiming Reticle anchored to the centre of the HUD represents the seeker's angular position and its field of view. By manoeuvring the aircraft you should line up its longitudinal axis with the source of radio illumination (precise alignment is not required) and then lock onto the target by pressing **Tab**.

The lock is evidenced by the change of information on the HUD (see the figure below): the Aiming Reticle, which represents the passive radar seeker, starts tracking the target, the range arrow indicates distance to the source of illumination, and the missile's flight time appears in the lower right-hand corner. Within a few seconds the Weapon Readiness Panel illuminates the selected missile with a green light showing its launch readiness. In the figure below the MFD indicates that an enemy radar is in front of you at a distance of about 8 km (MFD scale is 16 km).



Manoeuvre your aircraft so that the Aiming Reticle stays close to the centre of the HUD - this prevents the target from breaking the lock. Once within launch range, the HUD shows the Shoot Cue. Fire and forget! The missile will do its job OK, since it is fitted with a passive seeker. After the missile has left the pylon, the WCS changes back to the mode which preceded the Lock-on Mode.

If range to the target is less than the minimum launch range, the WCS outputs the Reject Cue '**OTB**' and disables the launch.

Using antiship missiles

As the name suggests, antiship missiles are intended for destroying ships (cruisers, destroyers, or patrol boats) using targeting information from the aircraft's onboard systems. Typical missiles of this type are Kh-31A (AS-12 'Kegler') and Kh-35 (AS-17 'Krypton').

To use antiship missiles you should enable your radar (press the **I** key). After you have spotted a target using information provided by the MFD, switch the radar from the Search in Narrow Area Mode to Autotrack Mode as described at the beginning of this chapter. Switching to Autotrack Mode instructs the WCS to download the target's coordinates to the antiship missile seeker (normally, employing active radar homing) and makes it possible to track moving ships.

After the radar has locked onto a ship, the HUD shows the 'A' Autotrack Cue as in the air-to-air combat modes. The HUD and MFD information will be similar to that shown in the figure below.

In Autotrack Mode the Aiming Reticle starts tracking the target across the HUD, the range arrow indicates distance to the ship, and the missile's flight time appears in the lower right-hand corner. Within a few seconds the Weapon Readiness Panel illuminates the selected missile with a green light showing its readiness for launch. Manoeuvre your aircraft so that the Aiming Reticle stays close to the centre of the HUD - this prevents the target from breaking the lock.

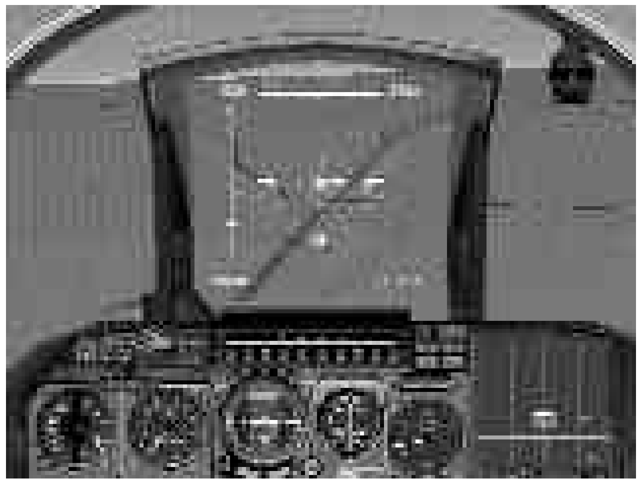
Note that control of the scan zone centre now becomes automatic; the radar antenna will be steadily directed to the target even if the latter is moving. As with tracking an airborne target, in Autotrack Mode the radar tracking area for azimuth and elevation angles is about 120°x120°, and radar tracking range for a medium-size target (for example, a patrol boat) is about 80-100 km.

As usual, when the HUD displays the Shoot Cue, fire!. Once the missile has been launched or you have cancelled the lock by pressing the **Tab** key, the WCS changes back to the mode which preceded the Autotrack Mode.

Firing unguided rockets and the cannon

Depending on the mission, you can use unguided rockets against armoured vehicles, hardened installations or other targets (fortified emplacements, personnel and aircraft protective shelters, runways). The S-8 and S-13 unguided rockets carried in special pods are widely used for these purposes.

You pick up targets for rockets either visually or by using the radar as described above. The MFD gets information either from the navigation system operating in Route Mode or from the radar, respectively. The HUD shows the Aiming Reticle, which corresponds to the current impact point, the minimum and maximum launch range marks, and the range to the impact point (q).



By manoeuvring your aircraft, superimpose the centre of the Aiming Reticle (a dot) on the desired target or on the diamond-shaped Radar Target Designator if you're targeting with the radar. Once within launch range, the '**ПР**' Shoot Cue on the HUD appears. Fire the rockets in brief salvos by repeatedly pulling the trigger. If the range to the impact point drops below the minimum launch range, the '**OTB**' Reject Cue appears interrupting further rocket launches.

Strafing targets with the GSh-301 cannon is very similar to shooting with unguided rockets. You activate the cannon by hitting the **C** key. The HUD shows the gun sight with a dot in the centre and the remaining rounds. All your following actions are practically the same as when using unguided rockets. Fire in brief salvos, remembering that the cannon fire rate is 1500 rounds per minute and that your ammo includes no more than 150 rounds. To disable the cannon hit C once more.

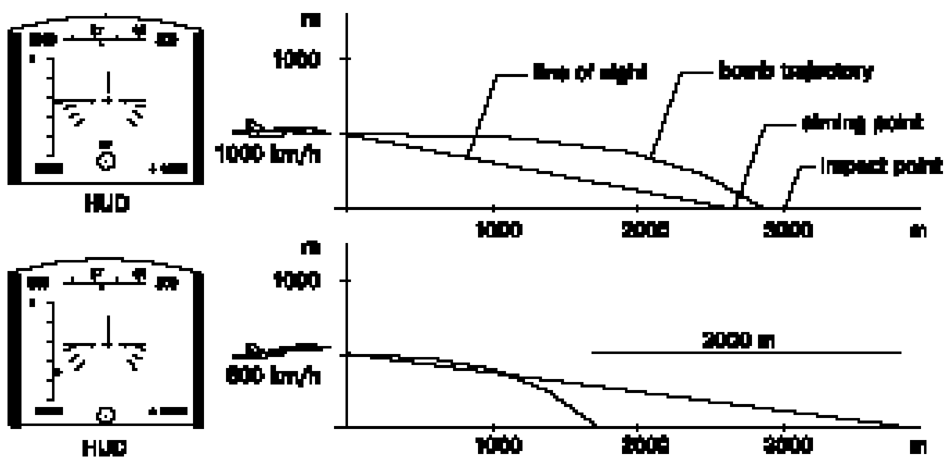
Dropping unguided bombs

Unguided bombs are traditional weapons effective against enemy fortification and military plants, railway junctions, and soft targets such as personnel and light armoured vehicles. Typical bombing altitudes for the Su-27 range from 300 to 1500 metres while typical airspeeds are from 500 to 1000 km/h. Note also that unguided bombs are usually dropped in pairs in order to not unbalance the aircraft.

Once again, you can select the target either visually or by using the radar. The MFD gets information either from the navigation system operating in the Route Mode or from the radar, respectively.

While using these weapons, the main task of the WCS is to calculate the Continuously Computed Impact Point (CCIP) and time remaining to the bomb release and project this information on the HUD. Your task consists in placing the CCIP Pipper on the target (or on the Radar Target Designator in the shape of a diamond) by manoeuvring the aircraft. Depending on the conditions of bomb delivery (height, distance to target, speed, etc.) you can drop a bomb immediately or switch the WCS to *aeronautical mode* as explained below.

Let's consider laydown bombing. Obviously, at a fixed altitude the bomb impact point moves forward if airspeed increases. Hence, the range from the release point to the impact point will increase while the angle between the horizontal line and the line of sight to the impact point will decrease (angle of attack increases as airspeed drops). In the figure below, laydown bombing is performed by two aircraft from an altitude of 500 metres and at airspeeds of 1000 km/h and 600 km/h, respectively. For the upper aircraft the bomb travel distance is 2800 metres, while for the lower one, 1700 metres. The angles to the impact point are 10° and 16°, respectively. The pilot's field of view in the forward-downward direction is limited by the HUD and constitutes 12°. By projecting the impact point onto the HUD and taking the AOA into account, we get 10.5° for the upper aircraft and 22° for the lower one. Thus, the CCIP Pipper in the first case comfortably lies within the HUD field of view while that in the second case is below the lower edge of the HUD.



The first case corresponds to conditions of immediate bomb release. However, the second case involves Aeronautical Mode since the moments of aiming and bomb release are different. The nearest ground point visible on the HUD of the lower aircraft is at a distance of 3700 metres. Thus, the lower aircraft needs to fly 2000 metres more till bomb release (which corresponds to 12 seconds of flight at 600 km/h).

This consideration can also be extended to dive and loft bombing. The pilot should take account of the wind as it drifts the bomb with respect to the aiming point. In the presence of wind it is recommended to perform dive bombing, which reduces the bomb fall time and, hence, the drift.

When using guided bombs there is no need to consider the influence of wind since it will be compensated by the bomb's guidance system. Since the trajectory of a guided bomb can be corrected within a certain area, this results in the appearance of two range marks on the HUD, which correspond to the minimum and maximum bomb release ranges.

Immediate bomb release

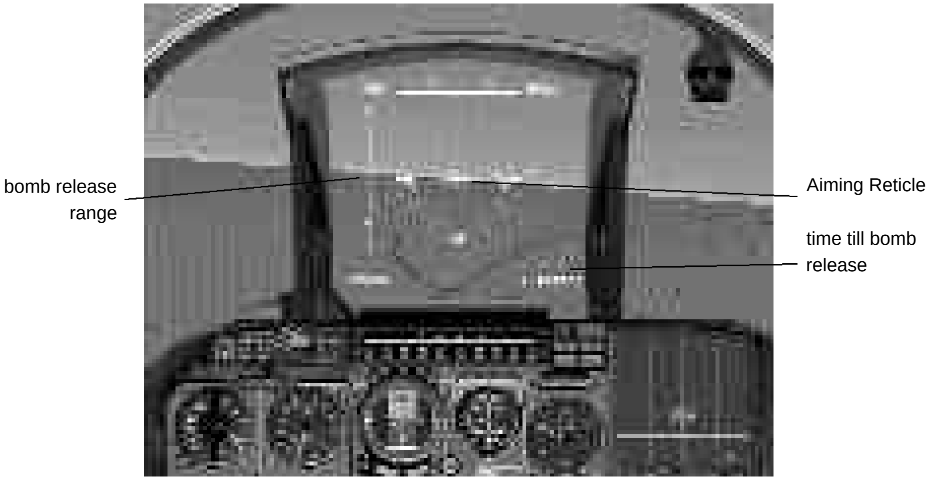
If the '**ПР**' Shoot Cue is displayed, you can pull the trigger (**SpaceBar**). This will release the bombs immediately, and they will hit the point designated by the Pipper. In so doing, the WCS switches back to the mode that preceded the bombing.

The figure below shows the HUD and MFD symbology when delivering unguided bombs with the help of the radar. Note that in the case below if you were to release at this very moment, the bombs would hit the point designated by the Pipper, rather than that tracked by the radar (the cross-roads) since the Pipper and the Radar Target Designator do not overlap.

Aeronautical Mode

If the CCIP Pipper is near the lower edge of the HUD and the Shoot Cue is not displayed, you cannot immediately release the bombs. The reason is that the ballistic characteristics of the unguided bomb will not permit it to reach the target. The only thing for the WCS to do is wait until your aircraft flies closer to the target while calculating the coordinates of the designated impact point. This is called Aeronautical Mode.

To enter Aeronautical Mode you should place the Pipper on the desired target, then pull the trigger (**SpaceBar**) and hold it pressed until bomb release. In Aeronautical Mode the WCS replaces the Pipper with the Aiming Reticle, which shows your lateral deviation from the designated impact point. Furthermore, the WCS calculates the time remaining till bomb release and displays the countdown in the lower right-hand corner of the HUD. The range from the bomb release point to the impact point is shown on the range scale as a single range mark. Now you should fly your aircraft so that the Aiming Reticle stays in the centre of the HUD: the closer the better. This will ensure that the unguided bombs will hit the designated point. Maintain the trigger depressed and wait until the remaining time counts down to zero: at that moment the bombs will be automatically dropped, and you can release the trigger. The WCS switches back from Aeronautical Mode to that which preceded the bombing. Note that if the countdown has a long way to go to zero you can release the trigger and depress it again when the countdown nears release point. The figure below shows the HUD symbology in Aeronautical Mode.



You can always cancel Aeronautical Mode by pressing Tab. If the trigger is not depressed the WCS will automatically switch out of Aeronautical Mode at the end of the countdown.

Dropping guided bombs

A guided bomb as opposed to an unguided one is fitted with a homing system (usually, TV or laser) and can correct the trajectory of its flight resulting in significantly higher accuracy.

Once again, you select the target either visually or by using the radar. In so doing, the MFD gets information either from the bomb's seeker or from the radar respectively. The HUD displays the Aiming Reticle showing an angular position and the field of view of the seeker.

After entering the target area turn off the radar transmission if it has been enabled (press **I**), and perform precision aiming using information output on the MFD from the bomb's seeker. If the bomb has a TV seeker, the MFD gets an enlarged terrain image with the cross-hairs. You can move the seeker's field of view by using the coolie hat or the scan zone control keys. As this takes place, both the Aiming Reticle on the HUD and the cross-hairs on the MFD move. By manoeuvring your aircraft, place the target into the seeker's field of view, superimpose the cross-hairs on the target's image. Lock the seeker onto the target by pressing **Tab**.

The lock onto the target will coincide with a change of information on the HUD: the Aiming Reticle starts showing your lateral deviation from the designated impact point. The maximum and minimum bombing range marks on the range scale and time remaining to leaving the bomb release zone appear. Within a few seconds the Weapon Readiness Panel will show bomb readiness.

You should manoeuvre you aircraft so that the Aiming Reticle stays close to the centre of the HUD - this prevents breaking the lock. When you enter the bomb release zone, the HUD shows the '**ПР**' Shoot Cue. Drop the bomb by pulling the trigger (**SpaceBar**) before you exit the bomb release zone (check range or time to leaving the zone). Note that the time interval for the bomb release can be quite short, so you can pull and hold the trigger right before entering the bomb release zone - this ensures that the bomb will be is dropped as soon as the Shoot Cue appears.

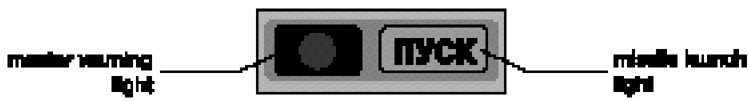
Chapter 7.
Warnings and Failures

Onboard warning systems are designed to give you timely warnings about possible damages to the aircraft and its onboard equipment, or about possible enemy threats. Correct and timely interpretation of the warning signals will help you successfully fight the enemy, save the aircraft, or at least your own life (when your only reasonable choice is ejection).

Master Warning System

The Master Warning System is designed to attract your attention to the vital information coming from various onboard systems. The MWS will activate the Master Warning Light and alarm beep. The frequency and duration of the flashing and alarm depend on the type of warning.

The Master Warning System alerts your attention to the following cases:



- Risk of ground impact
- Low fuel
- Lowered landing gear at a high airspeed
- Failure of some on-board equipment or damage to the aircraft construction
- Your aircraft is being painted by enemy radar
- A missile has been launched in the direction of your aircraft.

A ground impact warning means PULL UP! The Master Warning Light flashes at 1 Hz along with the audible alarm. This is accompanied with a diagonal cross-hairs indication on the HUD. Duration of the warning depends on the time your aircraft stays in these dangerous conditions.

A low fuel warning informs you that you should consider landing soon. The Master Warning Light flashes at 1 Hz and the audio signal beeps for 10 seconds. In so doing, the red Low Fuel Light "**ТОПЛИВО**" (pronounced 'top-li-vo') on the Fuel Gauge stays on.

A warning to retract the landing gear comes up when you exceed the maximum permissible airspeed with the landing gear deployed. The Master Warning Light flashes at 1 Hz and the audio signal beeps. Both warnings stop as soon as you retract the landing gear.

Any failures to the onboard-equipment are duplicated by the corresponding warning light. Evidence of the aircraft being painted is also shown on the TWD. The missile launch in your direction is witnessed by the Missile Launch Light. The detailed description of all these lights follows below.

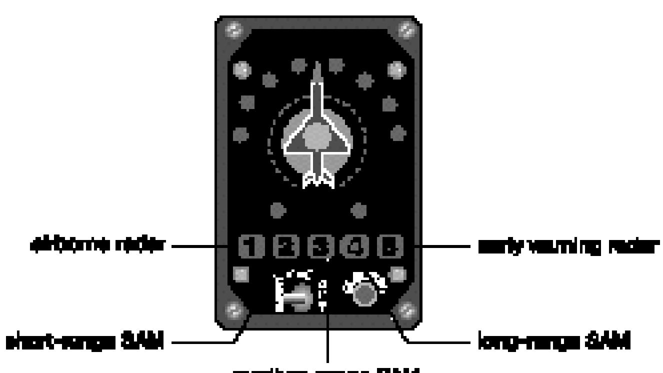
Once the problem is identified, you can reset the Master Warning by pressing the **M** key.

Radar Warning System

The SPO-15 "Beryoza" Radar Warning System (RWS) operates in passive mode. It detects external radar emissions, determines the direction to the source of illumination and the radar type. Two RWS antennas are fitted in the tailcone of the Su-27. It should be noted that this system is also installed on many other Russian aircraft, such as the MiG-29 Fulcrum, Mig-31 Foxhound, and even the Mi-24P Hind helicopter.

Information received by the RWS is displayed on the MFD as radar symbols and on the Threat Warning Display as yellow lights arranged around an aircraft silhouette.

The TWD is located in the lower right-hand corner of the instrument panel. Lights surrounding the aircraft's silhouette show the direction to the illumination source. If a light starts flashing with a particular frequency this means that a radar source in that direction is illuminating your aircraft at that particular sweep rate. When an illuminating signal sweeps with short intervals (this means that enemy radar has locked onto you), the corresponding flashing light changes to permanent and the aircraft silhouette in the centre of the TWD lights up. If the RWS can determine the type of illuminating radar a number at the bottom of the TWD will be highlighted. The numbers should be interpreted as follows:



Note that all Russian combat aircraft are equipped with Identification Friend or Foe (IFF), allowing the RWS to distinguish between illumination by hostile or friendly radar. This system also replies to friendly radar enabling it to lock off your aircraft. The Su-27 is equipped with the Parol (Password) IFF system.

When a radar beam has swept over your aircraft, the Master Warning Light starts flashing at a frequency of 5 Hz and the audio alarm starts beeping. If the enemy radar keeps illuminating your aircraft (has locked onto it), the Master Warning Light flashes and the audio alarm beeps simultaneously at a frequency of 1 Hz. To reset the current master warning, press **M**.

Missile Launch Warning System

The infrared MLWS can detect missile launches in the direction of your aircraft at comparatively close distances. The system operates in passive mode within the infrared region of the spectrum and makes it possible to detect sources of intense heat emission such as the hot gases formed by a solid-propellant rocket motor burn. The effective range of the system depends on the intensity of the heat emission and averages about 15 km.

The Missile Launch Light '**ПУСК**' (pronounced 'pusk', stands for LAUNCH in Russian) located on the Warning Panel to the right of the Master Warning Light shows the operation of the MLWS. When the MLWS has detected a missile launch, the light comes up and the audio alarm sounds at a frequency of 2 Hz for 5 seconds. Then the audio alarm goes silent and the light remains on until the rocket motor burn cannot be detected by the system. When the Missile Launch Light is activated it might be time to deploy chaff and flares (for more information turn to Chapter 8 "Understanding SAMs and Countermeasures").

System failures

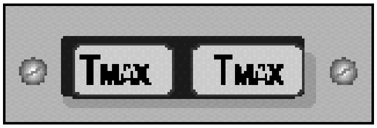
In combat your aircraft might be damaged as the result of a missile or shell hit. It is vital for you to know how to recognise and react to failures of the following systems:

- Power plant;
- Automatic control system and hydraulic system;
- Instruments (Altimeter, Airspeed Indicator, etc.);
- Special electronic equipment (radar, EOS, RWS, HUD, etc.).

The onboard warning systems are responsible for detecting various failures of onboard systems and notifying the pilot. Some failures can be recognised only by the instrument malfunction (dormant failures). If your aircraft is in trouble and the warning system can recognise the failure, an alarm starts beeping for 2 seconds and the Master Warning Light keeps flashing at a frequency of 1 Hz. The corresponding system failure indicator lights up along with the Master Warning Light. You can reset the MWL by pressing **M**.

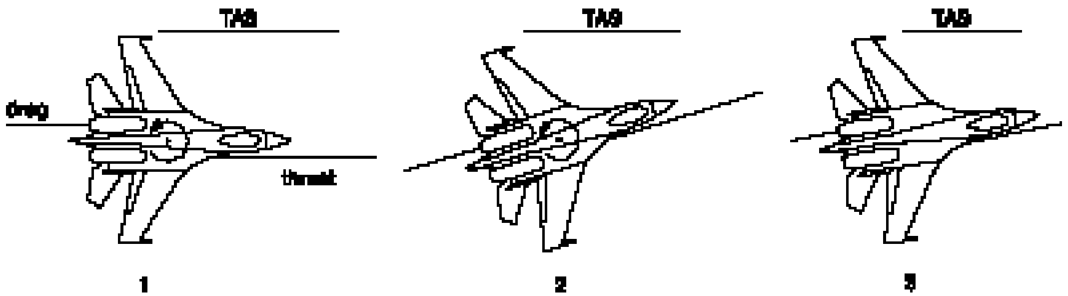
Power plant failures

Failure of the power plant may be caused by a missile hit and could lead to a spontaneous increase of gas temperature at the turbine exhaust and a drop of the RPMs of one or both engines. This situation is immediately reflected on the RPM Indicator and on the Jet Pipe Temperature Indicators. When the temperature exceeds the permissible threshold, the corresponding Max Jet Pipe Temperature Indicator will light up.



The damaged engine shuts down automatically, and the fire extinguishers are activated. If both engines are dead, eject! However, if only one engine has been damaged, you have a chance of getting home. Proceed as follows.

Since the vector of thrust of a single engine doesn't go through the Su-27's centre of mass, then a failure of one engine leads to the aircraft yawing in the direction of the failed engine (see Aircraft 2 in the figure below). The greater the thrust of the good engine, the greater the rate of yaw. As the thrust of the good engine increases, the FCS becomes incapable of adequately providing stability augmentation to the lateral and yaw control circuits to compensate the slip. If the aircraft develops roll in the direction of the failed engine, you should throttle back and try to stop the roll with the rudder pedals. Thus, if the aircraft is rolling left, push the right pedal forward. As soon as the rolling stops, ease the right leg (press **X** while holding down the **Z** key). Now you can fly level with slip in the direction of the good engine. Return to base and land using the rudder pedals. To facilitate the task of flying on one engine consider the option of dumping fuel (the **L** key) and weapons (**Ctrl+W**) which lightens the aircraft making it easier to fly.

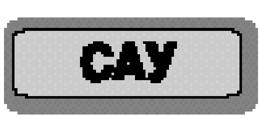


Failures of the automatic control system and hydraulic system

This group includes the following:

- Hydraulic system failure;
- Automatic Control System (ACS) failure;
- Automatic control regulation system failure.

When the hydraulic system fails, the '**ГИДРО**' (pronounced 'gid-ro', stands for HYDRO) indicator lights up. This kind of failure results in the loss of control of flaperons, slats, and air brake. Such a system failure also results in limited taileron and rudder authority.



In the event of the ACS failure the '**САУ**' (pronounced 'sau', stands for ACS) indicator lights up. This type of failure causes disturbances in the ACS operation in Autopilot and Altitude Stabilisation modes. The pilot has to turn off the current automatic flight mode.

A failure of the automatic control regulation system is also shown by the '**САУ**' Indicator. This kind of failure leads to automatic switching of the SDU-27 Flight Control System (FCS) to rigid link mode. This cuts off the "soft" regulation of signals from the control stick and ACS by the SDU-27. In this mode the backup FCS computer will give the pilot "proportional" control: a certain % of stick movement results in the same % of control surface movement. The aircraft becomes uncontrollable at slow airspeeds and badly reacts to stick deflections at high airspeeds. You have to turn off the current automatic flight mode (if it has been enabled) and try to maintain an airspeed of about 500-600 km/h while heading for the airfield. Try to make small stick deflections. Make an approach at 400 km/h. Aim to touch down at 270 km/h.

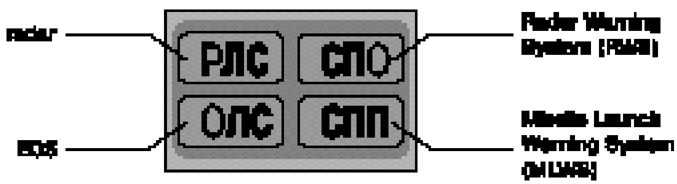
Instrumentation failures

If the pitot head has been damaged, this leads to disturbances such as the operation of the Airspeed Indicator and Barometric Altimeter, which manifest themselves as discrepancies between readings of the instruments and real values of the parameters.

You can recognise this kind of failure either by disturbances in the operation of the ACS and automatic control regulation system or by the discrepancy of the engine RPMs to the current altitude and airspeed (indicated airspeed usually falls).

Failures of special systems

Some special systems failures are indicated by four lights on the Warning Panel:



These failures manifest themselves in the following ways:

- The '**РЛС**' (pronounced 'er-el-es', stands for Radar Location System) light shows a failure of the RLPK-27 radar. The '**И**' Radar Cue on the HUD disappears and information on the MFD changes if it received information from the radar.
- The '**ОЛС**' (pronounced 'ols', stands for Electro-Optical System) light shows a failure of the EOS. The '**Т**' EOS Cue on the HUD disappears.
- The '**СПО**' (pronounced 'es-pe-o', stands for RWS) light shows a failure of the Radar Warning System. If this type of failure occurs, the lights on the TWD go out and radar symbols, if any, on the MFD disappear.
- The '**СПП**' (pronounced 'es-pe-pe', stands for MLWS) light shows a failure of the Missile Launch Warning System.

The following failures may also happen in combat:

- Failure of the passive countermeasures system is accompanied by zeroing of the Chaff/Flare Counter. This means that you will not be able to apply chaff/flare anymore.
- Failure of the Helmet-Mounted Target Designation (HMTD) system cancels combat operation of your helmet. The Targeting Circle disappears and you will not be able to designate targets in Helmet Mode.
- Failure of the HUD results in its shutdown. You have to fly on instruments and you definitely can not fight since the HUD is the main link between you and the Weapons Control System.
- Failure of the ECM system. You cannot apply active jamming if the ECM system is damaged.

Chapter 8. Understanding SAMs and Countermeasures

Although our program is an aircraft simulation, you will soon find that not only enemy aircraft haunt you. Both Russian and Ukraine air defence (PVO) units, PVO Ground Forces and Navy have extensive anti-aircraft artillery (AAA) and surface-to-air missile launchers (also known as SAMs or SAM sites) in service. Since AAA and SAMs play significant roles in modern air war, the pilot should be aware of what types of surface-to-air weapons he might come across and how to counteract them.

Anti-Aircraft Artillery

In general, AAA is effective against low-flying targets and mainly serves for covering troops from enemy aircraft. Many armies have muiti-barreled mobile AAA systems fitted with radar and a fire control system that provide effective operation in any meteorological conditions. In distinction to Ground Forces, shipborne artillery usually has a multipurpose character and fighting against airborne targets is just one of their many functions.

An AAA shell consists of a warhead, an impact fuse that detonates at the moment of contact with the target, and a "time fuse" which detonates after a particular flight time. The target is generally destroyed by the fragments produced by the warhead on detonation.

AAA of Ground Forces

ZSU-23-4 Shilka

The ZSU-23-4 Shilka (pronounced 'shil-ka') is a cannon anti-aircraft system mounted on an armoured tracked chassis. It has high off-road capabilities and is intended for destroying low-flying airborne targets while static or in motion and in all weather conditions.

The armament of the Shilka consists of four 23-mm cannons mounted on a rotary turret. The effective range is 2500 metres for targets flying at altitudes up to 1500 metres. The fire rate is 3400 rounds per minute (rpm). The onboard ammunition pack contains 2000 rounds.

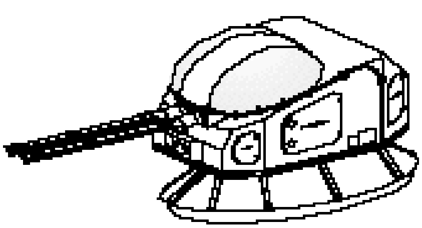
To search for airborne targets, the Shilka normally employs continuous-wave radar that can detect a typical target at a range of 20 km. Under conditions of ECM, the Shilka can detect and track targets with an IR sight.

Shipborne Artillery Systems

To destroy low-flying airborne targets, battle ships use multipurpose guns that can also be used against enemy ships and coastal defence. For the most part, shipborne artillery is classed as 100-130-mm guns (heavy calibre), 57-76-mm guns (medium calibre) and 20-40-mm guns (small calibre). All guns have a high degree of automation of aiming, loading, and firing.

A heavy or medium calibre multipurpose artillery system is highly automated and capable of operating in very rough seas and in any weather. Such systems consist of two major parts, one of which is located above the deck, the other below the deck. The below deck part contains ammunition, shell lift, control posts and so on. The above deck part consists of a rotary turret with one or more barrels. Against airborne targets such guns use shells with blast-fragmentation warheads and radio proximity fuses detonating in the vicinity of the target. The effective range of a heavy gun is about 20-25 km. Its altitude range is 10-12 km and fire rate is 35-60 rpm. Medium calibre guns have significantly higher rates of fire from 400 to 500 rpm and effective ranges of 10-13 km.

Automatic small-calibre (20-40 mm) anti-aircraft guns are mainly effective as a means of defence against low-flying aircraft and cruise missiles. Since SAMs normally have a substantial dead area, within which airborne targets cannot be hit, ship-borne AAA should be used in such cases. Indeed, if a low-flying target has been detected close to the ship, the systems usually have time to launch no more than one SAM. Furthermore, the efficiency of launching a SAM at a target flying above water surface at an altitude of 5-15 m is low due to sea clutter. That is why, to destroy targets that have broken through air defence, the ship uses muiti-barreled high firing rate AA guns having a fire rate of about 1000 rpm per barrel. 30-mm guns have an effective range of 5000 metres; however, range is less important than rate of fire and density of fire.



The operator controls fire using targeting information from the shipborne systems. Such systems include radar for detecting and tracking targets and a fire control system that computes the collision point and controls barrels in horizontal and vertical planes. The barrels are aimed automatically at an angular rate of 40-70° per second, which allows high-speed airborne targets to be hit at close range and heavy ship roll and pitch. A typical shipborne artillery system (the AK-725) is shown in the figure.

The table below presents specifications of the most widely used shipborne automatic artillery systems:

Type	Calibre, mm	Class	Fire rate, rpm	Range, km
AK-130	130	2-gun	35	29
AK-100	100	1-gun	60	21
AK-726	76.2	2-gun	400	13
AK-176	76.2	1-gun	500	10

Type	Calibre, mm	Class	Fire rate, rpm	Range, km
AK-725	57.0	2-gun	400	13
AK-630	30.0	6-barrelled	5000	5
AK-230	30.0	2-barrelled	2100	6
AK-306	30.0	1-barrelled	1000	5

Understanding SAM Systems

Surface-to-air missile

The main elements of a SAM (airframe, guidance system, fuse, warhead, and rocket motor) are similar in design and functions to those of AAMs. In addition, aerodynamic control of some types of SAMs can be complemented by exhaust-deflector vanes.

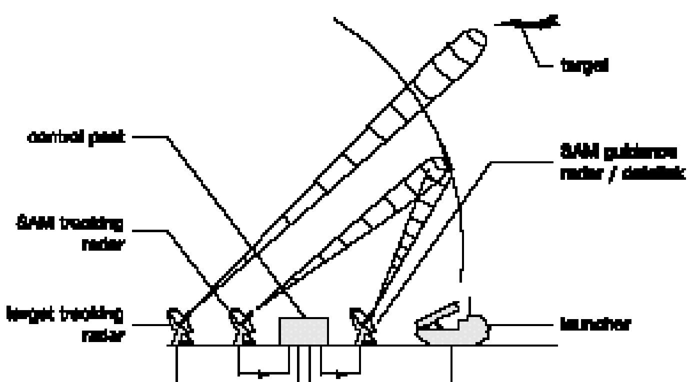
The flight trajectory of a SAM, as well as the composition and principle of operation of the autopilot are governed by the guidance method employed. The autopilot on its own or with the help of ground facilities continuously calculates relative positions of the SAM and the target and provides commands to the control surfaces.

Guidance for SAMs can be classified as one of the following: command, beam-rider guidance, homing (active, semiactive and passive), and combined guidance.

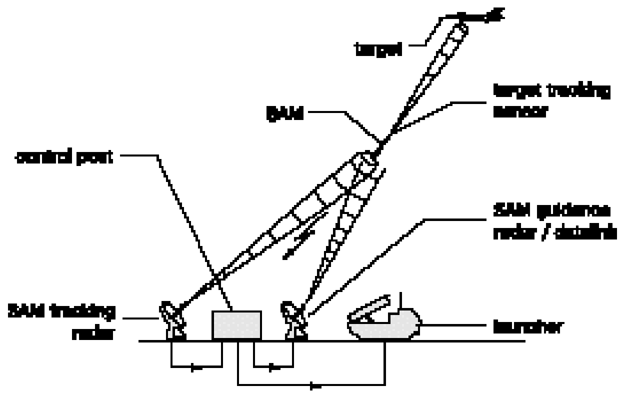
Command guidance

Command guidance may be compared to classic remote control. During the SAM's flight the positions of both the target and the missile are monitored from the ground or by the missile's onboard equipment.

If a SAM is guided by the ground facilities (see the figure below), the latter are responsible for detecting the target, measuring its coordinates and those of the SAM. After processing the coordinates the control post forms encoded guidance instructions and transmits them to the missile by radio data link, which is susceptible to jamming. After decoding by the missile's onboard equipment the commands are sent to the autopilot. This type of command guidance is normally employed in short-range and medium-range SAM systems such as the Tor (SA-15) or Osa (SA-8 'Gecko'), since the guidance accuracy decreases as the range increases.

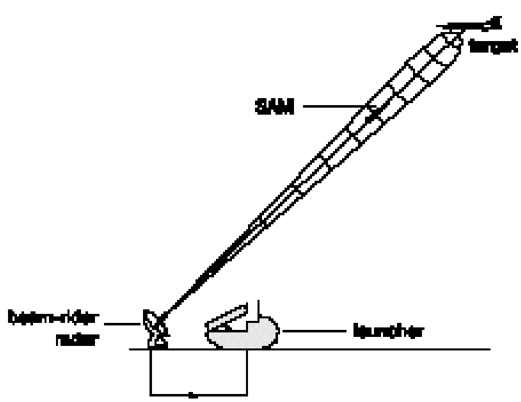


If the SAM itself can track the target, it measures and processes the parameters of the target's motion and sends them to the control post through radio data link. The coordinates of the SAM itself are measured by a ground-based tracking radar. Again, after comparing co-ordinates of the SAM and of the target, the control post sends guidance commands to the SAM. In systems of this kind the guidance accuracy does not depend on range, however, the onboard equipment is more sophisticated. Long-range SAM systems such as the S-300 (SA-10B ''Grumble') usually employ this type of command guidance in mid-course.



Beam-rider guidance

Beam-rider guidance is somewhat similar to command guidance along the line of sight between the target and the tracking radar, except that the missile guidance system is designed to seek and follow the centre of the guidance beam automatically, without specific correction instructions from the launching platform. The guidance beam is provided by a ground-based target tracking radar, and it "highlights" the direction to the target. Like command guidance systems, beam-rider SAM systems are not limited to daylight and good-weather conditions.



One problem with beam-rider systems, as with command ones, is that the SAM must have high manoeuvrability in order to intercept an evasive target. As they approach the target, beam-rider missiles often must tighten their turns continually to keep up. At high speeds tight turns may exceed the missile's capabilities. Using two radars, one for target tracking and a second for missile tracking and guidance, can reduce this problem somewhat by providing a more efficient lead trajectory. Beam-rider guidance is usually more accurate and faster-reacting than command guidance systems.

Homing

The most effective type of guidance against evasive targets is homing, when the missile guidance system gets information about the target and produces control commands on its own. Thus, the control post does not guide the SAM.

For active homing the SAM illuminates the target and receives the signals reflected off the target. In the case of semiactive homing, the source of illumination (tracking radar) is located at the control post, and the SAM again gets signals reflected from the target. Passive homing systems use heat or light energy emitted by the target to estimate the parameters of the target's motion. This kind of homing is implemented in the Strela-10 SAM system (SA-13 'Gopher').

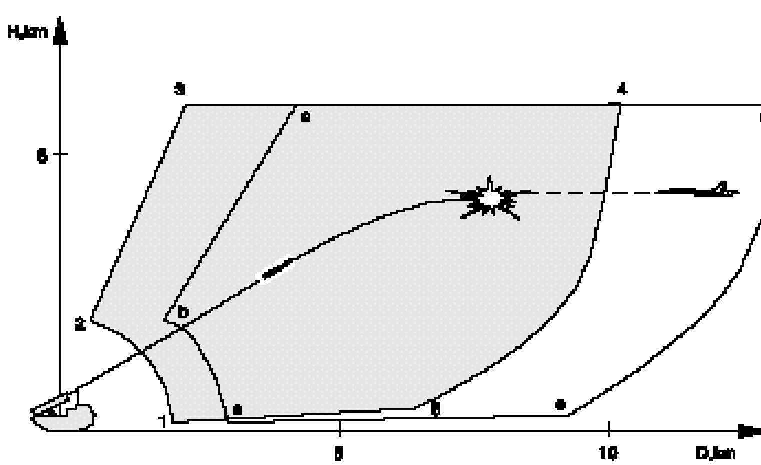
In general, homing systems operate in the following way: while the SAM rests on the launcher its seeker is locked onto the selected target, the parameters of the target's motion being measured. After launch the SAM seeker tracks the target, estimating the tracking error and produces control commands independently from the ground.

Combined guidance

The Kub (Cube) SAM system (SA-6A 'Gainful') is an example of a system with combined guidance. This system employs radio command guidance on the initial part of the missile trajectory and homing when closing in on the target. This provides high accuracy at long range.

SAM engagement envelope

The performance of a SAM system mainly depends on its engagement envelope, within which the system tracks and hits airborne targets with a given probability (the grey area 1-2-3-4-5 on the figure below). A typical engagement envelope is limited by maximum and minimum launch ranges and altitudes. The more central the target to the envelope, the higher the kill probability. Note that if we consider a moving target the envelope shifts as shown in the figure (the a-b-c-d-e area). This means that the missile can be launched even if the target has not yet entered the SAM engagement envelope but is closing in to it.



Typical SAM engagement envelope

The position of the upper and right boundaries of the envelope mainly depends on the energy capabilities of the SAM and quality of its tracking system and autopilot. This boundary defines the altitude and range to the collision point providing engagement effectiveness not less than a given threshold. Since the SAM trajectory depends on target speed, altitude, and course, the position of the envelope boundary is calculated for a particular given speed of the target.

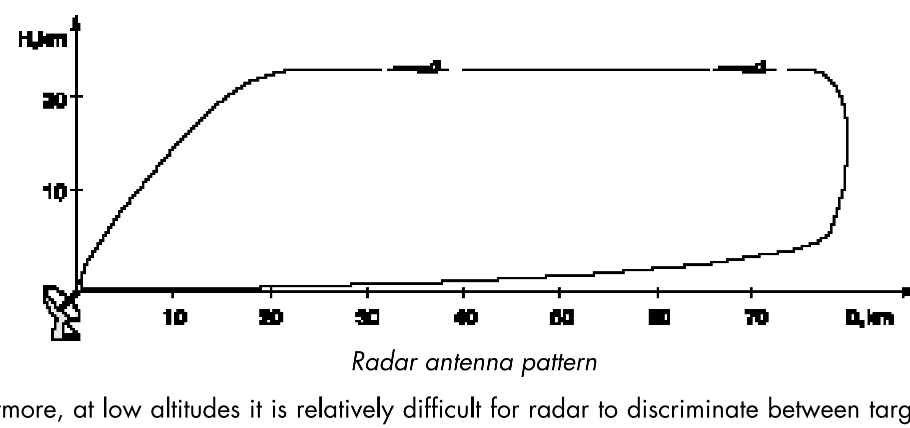
Maximum effective range of the tracking system is governed by the target effective reflection area and altitude and may vary substantially. If for a certain target the effective range of the radar is less than that of the SAM, this will decrease the engagement envelope. The effective range is the primary characteristic of any SAM system, so we can classify SAM systems as follows:

- Long-range SAMs (> 100 km).
- Medium-range SAMs (20 to 100 km).
- Medium-and-short range SAMs (10 to 20 km).
- Short-range SAMs (< 10 km).

The position of the lower boundary of the engagement envelope depends on the radar's ability to detect and track low-flying targets and on the ability of the SAM to fly at low altitude without crashing into the ground. Besides, the proximity fuse should not mistakenly detonate near the ground by confusing the latter with a target.

Many factors such as curvature of the ground surface, reflection of radio waves from the ground, and ground clutter, limit the possibility of detecting a low-flying target. Ground curvature limits the line-of-sight range, which affects operation of long-range and medium-range SAMs. Indeed, if a radar antenna is located at ground level, then the radio horizon dip is about 20 metres at a distance of 20 km and 150 metres at a distance of 50 km. The dip of the radio horizon increases proportionally with the square of distance. This means that it will be impossible to detect a target flying at an altitude of less than 150 metres while at a distance of 50 km. Lowering the radar beam will not help as it will only create further ground reflected interference which further reduces range.

The figure below shows a typical antenna radiation diagram as a function of distance and altitude.



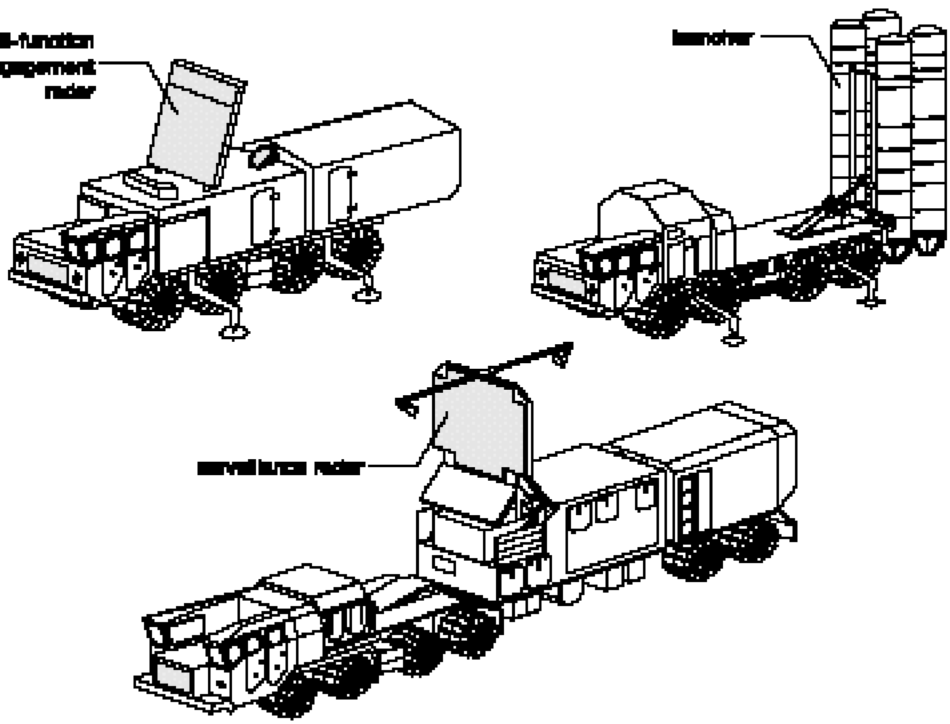
Radar antenna pattern

Furthermore, at low altitudes it is relatively difficult for radar to discriminate between target returns and returns from local objects such as towers, moving heavy goods vehicles, etc. Reflection intensity of local objects may vary depending on their material, size, shape, surface smoothness, etc. Consequently, returns from local objects depend on the specific operating conditions of the radar. These returns may lead to errors of measurement of angular position and range to the target, which will adversely affect the quality of guidance and may break the target lock.

To aim a SAM at a certain point, most SAM launchers are equipped with horizontal (for azimuth angles) and vertical (for elevation angles) mechanisms. Such SAM launchers are called rotary. This makes it possible to launch the SAM in the optimal direction hence reducing an initial vectoring error and bringing the near boundary of the SAM envelope closer. Modern SAM systems also use vertical launchers which permit simultaneous multi-direction launches.

Long-range SAMs

S-300PMU



The multi-channel mobile S-300PMU (SA-10B 'Grumble') was designed by the Grushin and Raspletin OKB and entered service in 1985. The S-300 serves for covering cities and industrial installations from enemy air raids, defending stationary control posts located in tactical depth. The system has a short reaction time, high degree of automation, and high firing capabilities (3 seconds per launch). It can simultaneously track 9 targets and independently fire at 6 targets, one or two SAMs to each. The S-300PMU can hit targets flying at speeds of up to 10000 km/h at altitudes from 25 to 30000 metres and has a guaranteed effective range of 90 km.

The system consists of the 64N6E ‘Big Bird’ phased array surveillance radar, the 36N6E ‘Flap-Lid’ phased array multi-function engagement radar capable of tracking stealth targets. The control post can manage up to 12 self-propelled launchers each carrying 4 SAMs. The ‘Flap-Lid’ radar rests on a single four-axle chassis with high off-road capabilities.

The S-300 launches SAMs in the upright position, which enables it to fire at targets approaching from any direction. This gives the system big advantages in conditions of intensive manoeuvring combat as this eliminates the necessity of turning the launchers beforehand to cover all directions.

The system employs the 48N6E SAM. It is a single-stage solid-propellant missile effective against any airborne targets (aircraft, helicopters, tactical and cruise missiles) at medium ranges in wide altitude limits. The 48N6E is fitted with a 143-kg blast-fragmentation warhead. The SAM blasts off upright from the launching container with a catapult to an altitude of 20-25 metres, then the rocket motor ignites. Blastoff acceleration may be as high as 100 Gs allowing the SAM to quickly pick up speed, which can reach 7500 km/h. In flight the 48N6E is controlled by exhaust deflector vanes and ailerons.

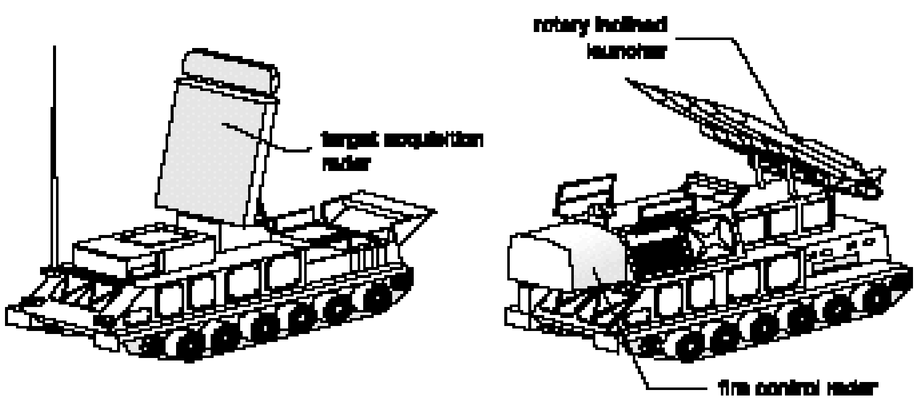
The S-300PMU employs inertial guidance in mid-course with commands from the 36N6E engagement radar and in the terminal phase semiactive track-via-missile mode. The 36N6E radar illuminates the target and the missile's onboard passive radar seeker receives a reflected signal. The SAM then relays this signal through an ECM-resistant data link to the control post computer. The control post then transmits control commands to the SAM. Such a method allows one to fit the 48N6E SAM with light and relatively cheap equipment and at the same time to use high-performance signal processing ground facilities.

Rif

The shipborne version S-300F Rif (Reef) with USA/NATO designation SA-N-6 'Grumble' is intended for defending ships from enemy aircraft and cruise missiles. The S-300F is effective against manoeuvring and sea-skimming targets. The SAMs blast off upright through launching hatches from the below-deck revolver-type launcher. The ammunition of the Rif may consist of 48 or 64 SAMs. This system is installed on the Slava class cruisers in 8 cell rotary launchers.

Medium-range SAM systems

Buk



The Buk (Beech, pronounced 'book') ground force SAM system (SA-11 'Gadfly') is designed by the Novator OKB and is effective against fast and agile aircraft, helicopters, and cruise missiles in conditions of massed air raids and intensive ECM. The Buk can simultaneously attack up to 12 targets flying at speeds up to 3000 km/h at ranges from 3 to 32 km and at altitudes between 15 and 22000 metres. The system reaction time is 8-10 seconds.

The Buk system has high mobility and combat survivability and consists of one control post, the 9S18 target acquisition station (NATO designation ‘Snow Drift’) and up to 6 self-propelled launchers. The phase array radar antenna of the target acquisition station is capable of detecting targets at a range of up to 100 km. Besides radar, the station has an IFF interrogator and a TV-optical sight. After the control post receives target acquisition information, it distributes detected targets by degree of danger: the most dangerous targets are assigned to available launchers. Using information from the control post or acting independently, the launcher's fire control radar (NATO designation ‘Fire Dome’) acquires a target and locks onto it at range of 70 to 85 km.

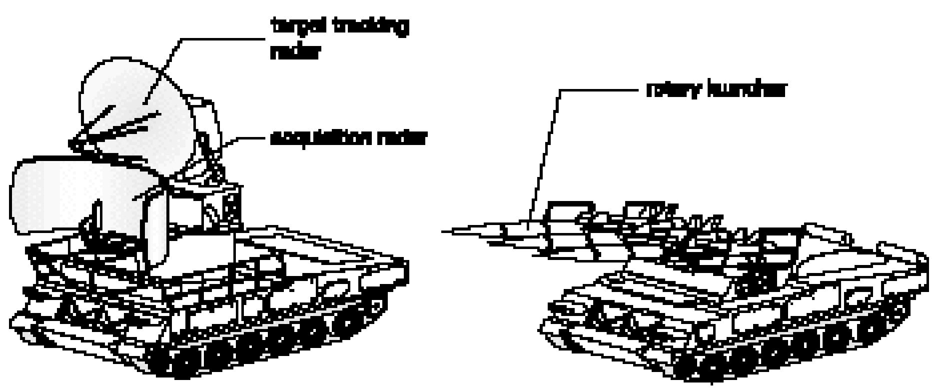
The Buk employs the 9M38M SAM with a single-stage solid-propellant rocket motor, semiactive radar seeker, radar proximity fuse, and 70-kg warhead. The SAM normally flies at Mach 3. Each launcher transports 4 SAMs which blast off from the rotary inclined launcher and hit targets with a kill probability of 0.7 to 0.9.

Besides the self-propelled launchers, the Buk can launch SAMs from 6 loading mounts (not shown in the figure on previous page) intended for transporting, loading, unloading and launching the SAMs. The mount normally carries 8 SAMs.

Shtil

The shipborne version of the Buk under the name of Shtil (Still) and USA/NATO designation SA-N-7 'Gadfly' is intended for air defence of both groups of ships and single ships against simultaneous attacks of anti-ship missiles and aircraft from several directions. The system operates in conjunction with the ship’s 360° surveillance radar and has built-in TV-optical sights. The SAM (unified with that of the Buk) blasts off from a rotary launcher with higher launch rate. The Shtil has several modifications and can simultaneously engage up to 12 targets.

Kub



The Kub (Cube, pronounced 'koob') ground-based SAM launcher (USA/NATO designation SA-6A 'Gainful') and the shipborne Shtorm (Storm) with USA/NATO designation SA-N-3 'Goblet' are SAM systems of the previous generation. The Kub entered service in 1967 and is effective against airborne targets at altitudes of 50-12000 metres and at ranges of 3.7-24 km. The system includes the 1S91 ‘Straight Flush’ acquisition and tracking radar supplemented by a TV-optical sight having with effective range of 20 km.

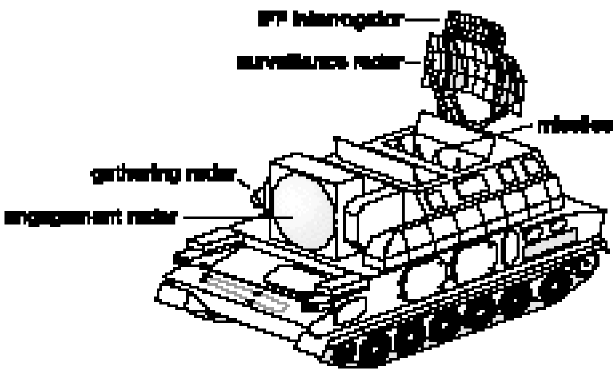
Besides the radar, the Kub system includes four rotary launchers with three 3M9M3 SAMs on each. The SAM is fitted with a 60-kg warhead, able to fly at a maximum speed of Mach 2.8 and employs combined radio command guidance with semiactive radar homing.

Shtorm

The Shtorm (Storm) shipborne SAM system (SA-N-3 'Goblet') was designed in the late 1960s for air defence and does not have an analogue in ground forces. The system consists of a rotary launcher with two ready for launch SAMs and an antenna post. The Shtorm employs the 4K60 SAMs intended for destroying airborne targets at altitudes of 100-25000 metres and at ranges of 3-55 km. The SAM is fitted with a 80-kg warhead, able to fly at a maximum speed of Mach 3 and employs radio command guidance. The Shtorm system is installed on the Moskva class aviation cruisers.

Medium-and-short range SAM systems

Tor



The Tor (Torus) (USA/NATO designation SA-15 'Gauntlet') is a mobile SAM system designed in 1988 by the Fakel OKB. The Tor can destroy enemy aircraft, helicopters, precision guided missiles, cruise missiles, guided bombs, and remotely piloted vehicles.

The unified tracked mount carries 8 SAMs on vertical launchers, a high-performance computer, a 'Dog Ear' surveillance radar and a phased-array engagement radar, which has an effective range of 25 km and can simultaneously detect 48 targets and track 10 targets, and a fire control radar which can simultaneously guide two SAMs. A small dome-type antenna on the top left of the engagement radar may 'gather' the missile as it is launched and hand it over to the engagement radar. The system reaction time is 5-8 sec.

The Tor employs the Fakel 9M330 SAMs with radio command guidance. The SAMs are stored and launched upright from the transport containers. After leaving the launcher, the SAM executes a corrective turn to the combat course using nose exhaust nozzles. Then the rocket motor ignites. The 9M330 has a maximum speed of 3000 km/h, maximum G-load of 30 Gs, an effective range of 1-12 km, and altitude limits of 10-6000 metres. The SAM can hit targets flying at speeds from 36 to 2500 km/h. The blast-fragmentation 15-kg warhead forms fragments having high penetration capabilities.

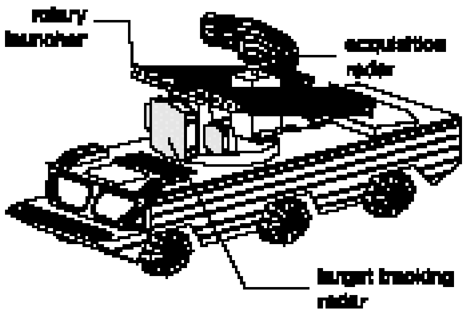
Klinok

The Klinok (Blade) (USA/NATO designation SA-N-9 'Gauntlet') is an autonomous all-weather shipborne SAM system intended for self-defence of military and civilian ships from massed attacks of low-flying antiship missiles, piloted and pilotless aircraft flying at low and medium altitudes. The system is installed on the Udaloy class destroyers and can simultaneously hit up to four targets.

The system has autonomous equipment for target acquisition providing independence from the ship's radar. It can detect targets at a range of about 45 km. The built-in TV-optical target tracking system has a range of 20 km and increased ECM-resistance in conditions of intensive countermeasures.

The below-deck launcher has several revolver-type launching modules. Each module houses 8 SAM containers. The ammunition complement may include 24-64 SAMs depending on the number of launchers in the system. The system employs SAMs similar to those of the Tor and having similar performances. The SAMs are launched upright using a catapult. On exit from the launcher, the nose exhaust nozzles vector the SAM to the target.

Osa-AK



The Osa-AK (Wasp) ground SAM system (SA-8B 'Gecko') and the Osa-M shipborne SAM system (SA-N-4B 'Gecko') are medium-range SAM systems of the previous generation.

The Osa-AK ground-based SAM system was designed by the Grushin OKB, entered service in 1980 and is intended for defending installations from guided missiles, guided bombs, aircraft, and helicopters. The Osa-AK has an effective range of 1500-10000 metres and can hit targets flying at a maximum speed of 1800 km/h at altitudes of 25-6000 metres. The whole system with its ammunition complement (six 9M33M SAMs in rotary launching containers) is mounted on a three-axle amphibious chassis with high off-road capabilities. The Osa-AK systems are usually combined into batteries of four launchers in each.

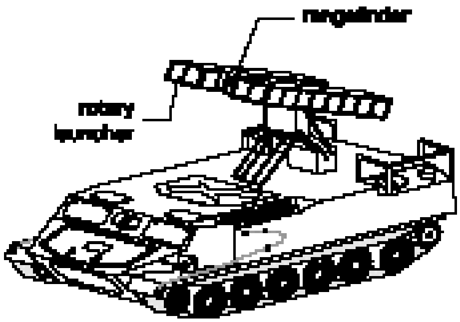
The system's 'Land Roll' radar is capable of detecting a typical target at a range of about 25 km. Besides radar, the Osa-AK is fitted with an optical sight assuring target tracking in conditions of ECM. The sight can track a target at a range of up to 20 km.

The Fakel 9M33M missile is fitted with a 40-kg warhead and a single-stage solid-propellant motor allowing it to travel at a maximum speed of Mach 2.5. The SAM employs radio command guidance. Probability of target destruction by one SAM depends on the target type and ranges from 0.4 to 0.95.

The Osa-M shipborne version has performances similar to those of the Osa-AK system. It is designed for self-defence of military and civilian ships from attacks of enemy aircraft flying at low and medium altitudes. The system consists of a rotary launcher with two ready-for-launch SAMs and an antenna post allowing it to operate autonomously. The Osa-M can also operate with targeting data from the ship's radar.

Short-range SAM systems

Strela-10M3



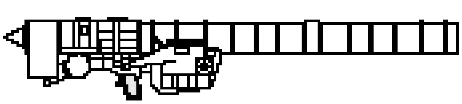
The Strela-10M3 (Arrow) light ground-based SAM system (SA-13 'Gopher') is intended for close-in troop protection from low-flying aircraft and helicopters, as well as for destroying cruise missiles and remotely piloted vehicles.

The Strela-10M3 is mounted on an amphibious armoured tracked chassis and includes four ready-to-launch 9M333 SAMs in containers on a rotary launcher. The radar operates in common with the missile seeker, which employs double-channel homing by photo contrast and IR target emission.

The Strela-10M3 also includes an IFF interrogator and a passive radio direction finder intended for detecting and finding precise directions to airborne targets flying with enabled onboard radio equipment.

The 9M333 SAM is fitted with a 4-kg warhead and a single-stage solid-propellant rocket motor, which allows it to travel at an average speed of 1800 km/h. The SAM can hit airborne targets at ranges of 50-5000 metres and at altitudes of 25-3500 metres.

Igla



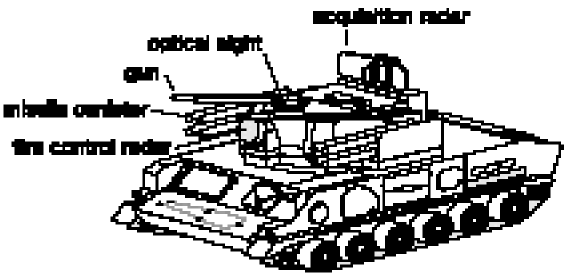
The Igla (Needle) portable SAM launcher (SA-16, 'Gimlet') designed by the Kolomna Machinery Design Bureau serves to defend small subunits, individual vehicles (tanks, infantry vehicles, self-propelled artillery mounts), small ships, and auxiliary vessel from air strikes. The Igla is intended for single shot launching from the shoulder. The shipborne version under the name SA-N-10 may use a quadruple launcher.

The Igla employs the 9M39 missile is fitted with a 1.2-kg warhead and a IR-homing system. The SAM allows one to down airborne targets flying at speeds of up to 1260 km/h at ranges of 500-

5000 metres and at altitudes of 10-3500 metres. A single-stage solid-propellant rocket motor allows the SAM to travel at an average cruising speed of 2000 km/h. The target destruction probability is about 0.4.

Combined AA gun-missile launchers

Tunguska

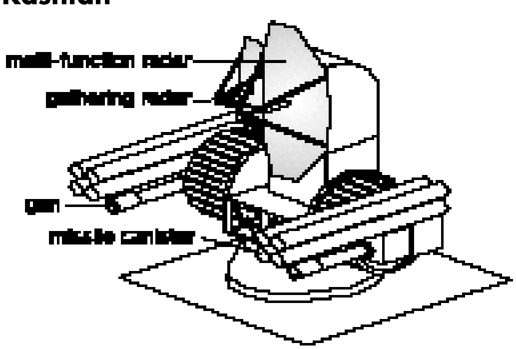


The Tunguska (SA-19 ‘Grison’) system is a gun/missile complex. It is the world’s first serial-production system which allows you to destroy targets both by missiles and artillery fire in all meteorological conditions both in daytime and at night. A typical Tunguska battery consists of six AA self-propelled armoured mounts and maintenance equipment.

The Tunguska self-propelled mount includes a ‘Hot Shot’ radar, an optical sight, two automatic double-barrelled 30-mm guns, and eight containers with the 9M311 SAMs. The AA guns having a total fire rate of 10000 rpm and muzzle velocity of 3500 km/h, provide an engagement envelope of 0-3000 metres for altitude and of 200-4000 metres for range. The guns can be employed from stationary position, during short stops, and in motion.

The 9M311 is a two-stage solid-propellant missile fitted with a 9-kg fragmentation/rod warhead and a proximity fuse with a fusing radius of 5 metres. The SAM has a maximum speed of 3200 km/h and an average speed of 2200 km/h. The 9M311 employs semi-automatic radio command guidance with manual target tracking and automatic placing of the SAM on the line-of-sight using signals transmitted through the radio data link. For SAMs, the system has an engagement envelope of 15-3500 metres for altitude and of 2500-8000 metres for range. The SAMs can hit airborne targets flying at speeds of 0-1800 km/h.

Kashtan



The Kashtan (Chestnut) shipborne gun/missile integrated weapon system (SA-N-11 ‘Grison’) is designed by the Tula machine-building plant and intended for close air defence of ships of all classes (from gunboats to aircraft carriers). The system is effective against antiship missiles, guided bombs, aircraft and helicopters flying at ranges of up to 8000 m.

The Kashtan consists of launchers designed for eight 9M311 SAMs (similar to those used by the Tunguska), radar, a TV guidance system, and two multi-barreled 30-mm guns with a total fire rate of 10000 rpm. The 9M311 missile is fitted with a 9-kg warhead and employs radio command guidance.

The Kashtan can fire SAMs on targets at altitudes from 4000 metres to extremely low altitudes and at ranges from 1500 to 8000 metres. Operation of the system is completely automated and is capable of firing at up to six targets per minute.

Early Warning Systems

Airborne warning and control system (AWACS)

AWACS aircraft provide constant surveillance of the current air situation over a very large area and give early warning to air defence units. A typical AWACS aircraft has a 360° all aspect radar and equipment for data processing and encoding. Such aircraft can collect and relay information about the air situation to ground (ship) command posts and guide interceptors to their targets. Furthermore, AWACS aircraft can be used to acquire ground (surface) targets and provide targeting data for strike aircraft.

The advantages of AWACS aircraft over ground (shipborne) radar include the ability to detect air borne targets flying at virtually any altitude, the ability to detect air borne targets flying at extremely low altitudes over the terrain with any relief, high mobility, and lesser vulnerability to various weapons. The main drawback of an AWACS aircraft is its long 'on station' patrolling role associated with its relatively high level of vulnerability, not to mention being a major focus of enemy attention.

A-50 AWACS aircraft

In early 1980s the Vega Scientific Production Association designed the Shmel (Bumble-bee) electronic complex. While being inferior to its American analogue E-3 AWACS in detection range and number of automatic guidance channels, the Shmel system effectively detects low-flying targets with small effective scattering area (cruise missiles, Stealth aircraft) and can relay highly encrypted data to practically any location via its satellite communication module. The system was installed onto IL-76MD transport aircraft by the Beriev OKB located in Taganrog. The AWACS aircraft was given the name A-50. The IL-76MD was chosen as the platform for the Shmel system due to its high airspeed (800 km/h) and radius of operation. The aircraft can patrol an area for up to 4 hours at 1000 km from base without refuelling. The relatively high cruise altitude (10000 metres) makes it possible to increase target detection range due to moving of the radio horizon, which equals 300 km at an altitude of 7000 metres, and 400 km at an altitude of 10000 metres.

The Shmel system of the A-50 includes a three-coordinate radar which measures target azimuth, range, and altitude. The radar antenna is housed in a 9 m fairing mounted above the fuselage. The radar detection range depends on the type of target and operational mode and can be as much as 400 kilometres.

The radar equipment of the A-50 aircraft provides long-range detection of airborne and naval targets, IFF confirmation, and guides aircraft of Air Force and Air Defence to the targets. Tactical crew of the A-50 consists of 10 people.

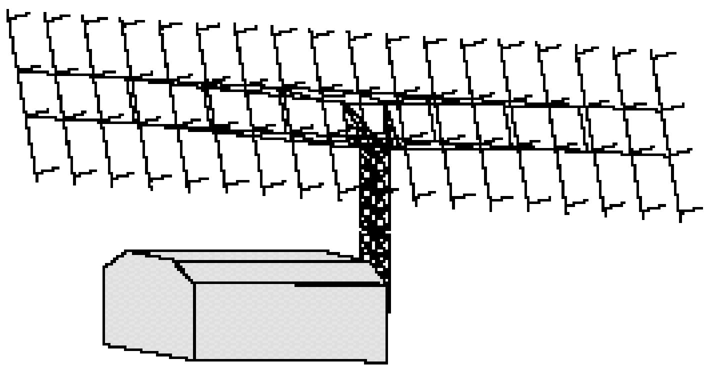
The A-50 has extensive ECM capability and combined chaff/flare cartridges, which provide defence from enemy fighters and ground-based antiaircraft systems.

During the Gulf War the A-50 aircraft flew patrol missions over the Black Sea and provided surveillance of the air space near the southern borders of the USSR. This allowed them to gather information about all fighters and transport aircraft which took off from Turkish airfields.

Early warning radar (EWR) stations

Tactical EWR stations are intended for target acquisition and designation, and provide radar information to SAM systems and air defence command posts.

1R13



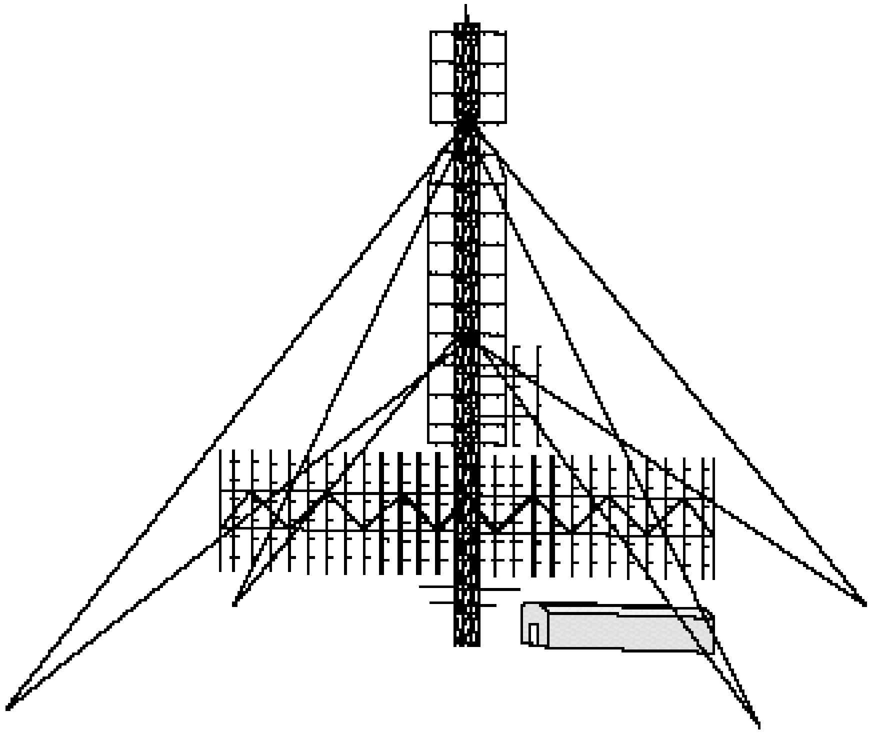
The 1R13 EWR station operates in the VHF wave band and can detect airborne targets and measure their co-ordinates (azimuth - range) at a long range in conditions of severe ECM. The system is capable of detecting the F-117A stealth aircraft. The 1R13 performs IFF confirmation and relays data to the command post through wire and radio data links.

The 1R13 radar measures the coordinates of targets in the entire range of azimuth angles at distances of up to 300 kilometres and elevation angles of up to 25°. The maximum detection altitude for a target of the fighter class is 27 kilometres and a typical detection range for a fighter flying at high 10 kilometres equals 230 kilometres. The information is refreshed every 10 seconds.

The radar antenna array is mounted on a three-axle trailer. It can be deployed from travelling position within 45 minutes. The whole system consists of four automobiles.

55Zh6

The 55Zh6 EWR station is equipped with a three-coordinate radar operating in the VHF wave band. The radar is intended for detecting and measuring coordinates of modern and future aircraft, helicopters, cruise missiles, and aerostats in the conditions of severe ground clutter and ECM. The 55Zh6 system can operate both as a part of automated control systems and standalone.



The system includes a phased array antenna attached to a mast and measuring 16x3.24 meters. The deployment time of the system is 22 hours. The 55Zh6 can detect targets at distances of up to 500 kilometres and at elevation angles of up to 16˚ in any azimuth angles. The detection ceiling of fighter class targets is 40 kilometres and the typical detection range at an altitude of 10 kilometres is about 300 kilometres. The system measures target coordinates with an accuracy of 500 metres in range, 24" in azimuth, and 850 meters in altitude. It provides refreshed data every 10 seconds.

Missile Defence

Missiles, be it AAMs or SAMs, pose a serious threat to your aircraft. The philosophy of successful missile defence is based on the concepts of passive defence measures, which include avoidance of zones of potential threat, and active defence measures, such as ECM jamming, chaff and flares, and evasive manoeuvring.

Passive defence measures

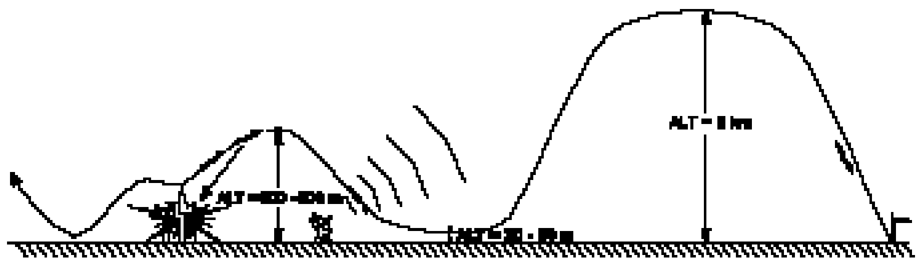
First of all, try to keep away from the areas of potential threat. Intelligence information may be provided to you at the mission briefing and/or in-flight, by AWACS. So, don't be hypnotised by the foretaste of the forthcoming combat, try to avoid being spotted. This can be achieved by flying at low altitudes or employing counter-radar manoeuvres

Keep a low profile

The Earth's curvature and terrain masking provided by hills, trees, etc., may limit the target acquisition range of SAM systems, which leads to a reduction of the time available to the enemy for effective air defence. Ground clutter is also a problem for radar-controlled SAMs, but unfortunately it can be reduced by Doppler techniques, phase array and alternative optical guidance systems.

Flying at extremely low altitudes (lower than the lower boundary of the SAM engagement envelope) theoretically excludes the possibility of being shot down. However, the pilot should take into account the greater effectiveness of small arms, AAA, and very short range SAMs, such as the Stinger or Igla portable SAM launchers. Within their operating envelopes most missiles can be expected to be more manoeuvrable at low altitude. Therefore, the faster you fly at low altitude, the less probability of being hit by AAA or short range SAMs due to an increase in target tracking errors.

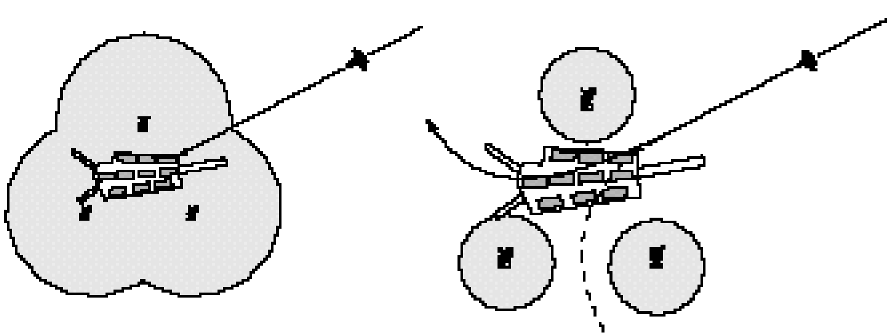
However, it should be noted that flying the plane at low altitudes requires increased attention and is very tiring. Low level operations may also limit the usefulness of the fighter's own weapons system. Because of this, you can use flight profiles with changing altitudes at various parts of the flight path. The figure below illustrates a typical mission profile Hi-lo-hi.



Hi-lo-hi mission profile

After the takeoff the aircraft climbs to 8 km to the point of potential detection by enemy air defence radars. Then the aircraft descends to an altitude of 20-50 metres and quickly passes through the radar detection zone while climbing to the altitude required for final reconnaissance and/or attack. In so doing, the fighter should employ ECM active jamming, chaff and flares if necessary.

Counter-radar manoeuvers are of vital importance before flying into detection areas. For example, a dive to low altitude discussed above is one of such manoeuvre. In the figure below you can see the combined detection area of three enemy radars for the aircraft flying high (left picture) and for that flying on the deck (right). As you can see, the low-flying aircraft in our case can get through the threat zone without risk of being detected.



Active defence measures

Passive measures are rarely 100% effective. Sooner or later the enemy will spot you. Once the Threat Warning Display (TWD) starts flashing and you hear the warning beep, it's time to get active and do something radical. To help you detect the enemy radars and missiles, the Flanker is equipped with the SPO-15 Radar Warning System (RWS) and Missile Launch Warning System (MLWS) - see Chapter 7 "Warnings and Failures".

The MLWS detects the missile launch and provides visual alarm sound beeps. The missile launch warning light '**ПУСК**' shows operation of the MLWS and means that a missile has been launched in the direction of your aircraft. Try to find out its range and most probable inbound trajectory. Should this missile be incoming within the sweep cone of your radar, the MFD will display the missile as an unidentified target symbol (small square).

As soon as you detect enemy radar painting your aircraft or a missile launch, you should execute a countermissile manoeuvre and employ countermeasures, which can be subdivided into two categories: jamming and deception (chaff and flares).

Evasive manoeuvring

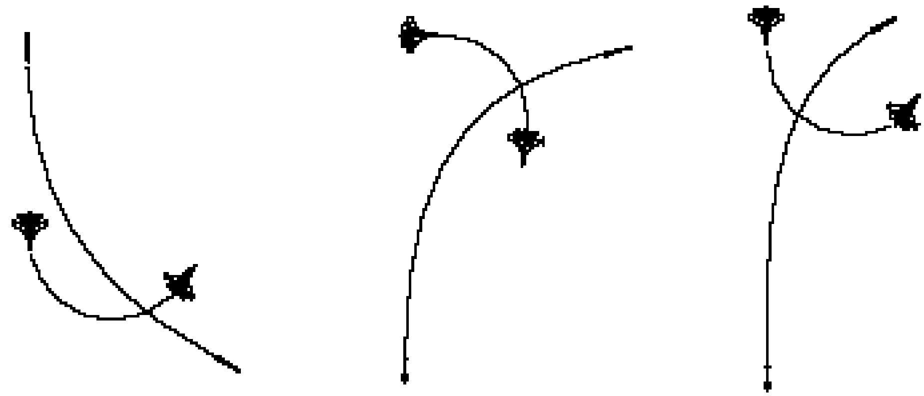
A counter-missile manoeuvre reduces the effectiveness of the missile's blast or completely outwits it avoiding any contact.

First, try to prevent the missile from being launched at all! Deny the enemy his required launch parameters, range, aspect, and aim. The more you know about your adversary's capabilities and limitations, the more effective your defensive tactics. Typically, this knowledge should include launch envelopes, aiming requirements, radar capabilities, and expected enemy tactics. In particular, counter-SAM manoeuvres may subject the aircraft to a dive, a steep half-spiral or fast change of course to the extent of turning in the opposite direction.

You should also take into account the fact that altitude has an important effect on missile range and effectiveness. In general, the range of both jet- and rocket-powered vehicles increases when they are operating at higher altitudes. Typically, missile range at 20,000 ft above mean sea level can be expected to be about double the sea-level value. However, the increased true airspeed of your aircraft at high altitudes will reduce the range of rear-quarter missiles and increase forward-quarter range.

Besides reducing the size of the missile's envelope, you can also fool the missile by generating line-of-sight (LOS) rates that exceed the missile's turn capability. The most effective counter-missile manoeuvre, which you can use against both SAMs and AAMs, is a break turn. There are several purposes for this break turn. One is to increase the LOS rate, making it more difficult for a missile to track and manoeuvre to an intercept. A second is to degrade seeker and guidance performance by moving the heat source away from a rear-hemisphere IR missile attack or by gaining a beam aspect against a radar missile. Attaining a beam aspect also may degrade fuse and warhead effectiveness. In addition, the break turn allows the earliest visual acquisition of the missile and/or launch platform. The direction of the defensive break turn depends on the aspect of the threat, and usually should be in the closest direction to achieve a beam aspect. For rear hemisphere missiles this generally means breaking towards the threat, and turning away from forward-hemisphere threats.

Lets illustrate how you can counteract to SAMs fired at your fighter from various aspects. To effectively execute a counter-SAM manoeuvre, you should first find out the location of the SAM site that is going to launch or has launched the SAM. On the Su-27 you can use the MFD for this purpose, which is showing a radar symbol, and the TWD, which will also show the type of enemy radar. Then you should choose the appropriate type of manoeuvre and direction of execution. Below are a few counter-SAM manoeuvres for different relative aspect angles.



Counter-SAM manoeuvres

Jamming

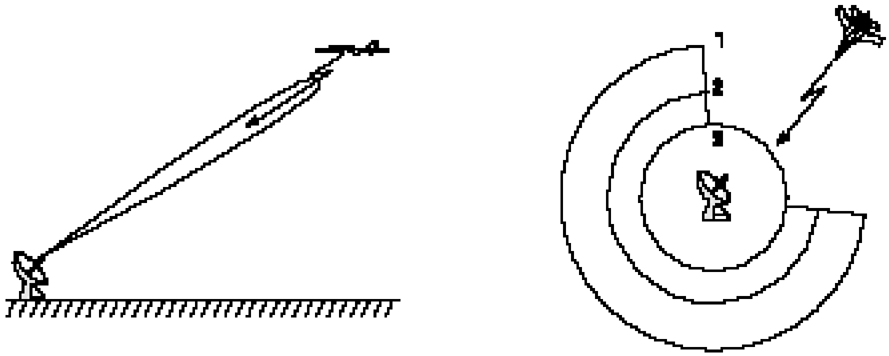
First of all, it should be noted that jamming can be passive or active. Passive jamming is designed to decrease fighter vulnerability to missile attack by using "camouflage" techniques. These include reducing the aircraft's radar reflectivity by using non-reflecting materials and radar-absorbing paint. Reflectivity is also sensitive to engine inlet design and placement, and to physical size and shape of various aircraft parts. IR signatures can be suppressed by using special jet-nozzle designs, by monitoring exhaust placement, and by adding chemicals to the exhaust. Even optical tracking can be made more difficult by using camouflage techniques that reduce the aircraft contrast with the background.

Active jamming (also called noise jamming) is created by the aircraft's own equipment or by a "stand-off jammer", for example, AWACS, which attempts to conceal other aircraft with its noise. The methods of active jamming may differ, but they are all based on producing a strong signal that will overpower the target return when it is received by the enemy radar. Besides jamming enemy radars, active jamming may also fool the missile seeker, fuse or command receiver.

The effectiveness of jamming is related to the ratio of the jamming power received by the enemy radar to the strength of the target's return. Since reflected target energy is much more sensitive to target range than is the received noise, active jamming is very effective at long distances. Noise is also more effective if it can be concentrated in a narrow beam at the enemy radar.

The ECM equipment transmits a continuous-wave signal that comes to the input of the enemy radar and suppresses the target returns. The most effective jamming signal which is difficult to filter is that modulated by white noise as its characteristics coincide with those of the receiver's own noise. Selective jamming has high power density; however, the jammer transmitter must be relatively accurately tuned to the frequency of the radar being jammed. This requires using corresponding intelligence-gathering equipment. Note that to jam a variety of radars, separate jammers should be used.

Sweep jamming has the advantage that one jammer transmitter jams all radars operating within a wide bandwidth. In this case the requirements of the intelligence-gathering equipment of the jammer are very moderate. However, the power density of sweep jamming is significantly lower than that of selective jamming, since the total power of a transmitter is spread over a wider frequency spectrum.



Selective (left) and sweep jamming (right)

In the figure above, the radar detection zone in the absence of jamming is marked by 1. In the case of barrage jamming the detection zone is smaller (2). And if the aircraft employs point-type (directional) jamming (3) it can close in to the radar at a maximum distance without being acquired.

Since for increased ECM-resistance many up-to-date radars operate with carrier frequency changing, *gliding (or quasi barrage) jamming* is the most efficient ECM against them. Gliding jamming covers a wide frequency band by quick frequency changes within a relatively narrow frequency band. This type of jamming does not require precise knowledge of the enemy radars operating frequency and is close to selective jamming by its high power density.

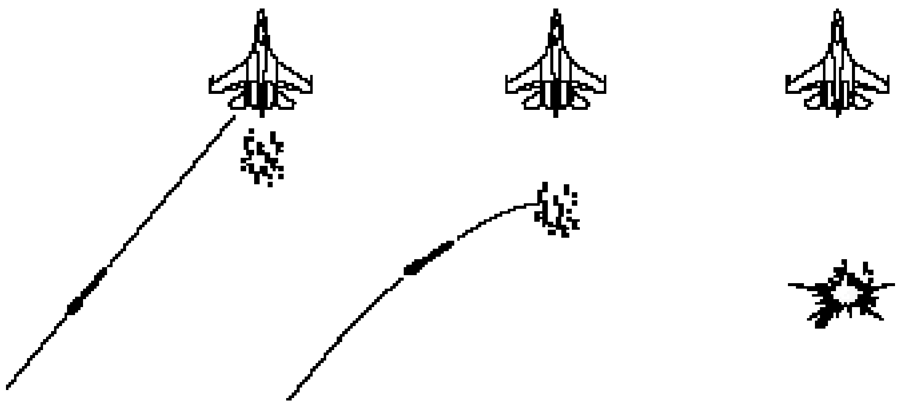
Deception jamming can imitate legitimate returns to the enemy radar, that is, to transmit the signal of the same frequency and duration as the target returns. This leads to "fooling" the enemy radar, since it "sees" spurious images or false targets at different ranges and azimuths. This complicates detection of real targets. Deception jamming may also mislead the enemy radar as to true range and speed of the target. This method of jamming is more effective than saturating a wide band of frequencies with noise, however, it requires that the jammer be matched exactly to the type of radar encountered.

We should note that regardless of the jamming form used there is one big drawback. The excess noise generated by the jammer makes it detectable at long ranges. Indeed, the jammer unmasks your aircraft. This means that if you turn on the jammer too early, that is, at a long range from the enemy radar, you increase the detection range, and the SAM will have additional time to prepare. Again, if you turn on the jammer transmitter too late, your aircraft may be shot down because SAM sites operate without hindrance. Therefore, using the jammer is a trade-off.

The active jamming equipment of the Su-27 normally includes a built-in onboard ECM pack, which provides the aircraft with self-defence from enemy airborne and ground-based radars. You can toggle the built-in jammer by pressing the **E** key. Operation of the active jammer is shown by the '**АП**' active jamming indicator on the instrument panel. To suppress enemy air defence radars during air-to-ground attacks or intercepts, the Su-27 can additionally carry the Sorbtsiya-S ECM system (analogue to the AN/ALQ-135 American jammer) installed into two pods on the aircraft wingtips. The system includes a receiver and a jammer-transmitter. It can detect and recognise illumination sources, and jam at an enemy frequency. If the enemy radar ceases operation, the jammer automatically turns off.

Deploying chaff and flares

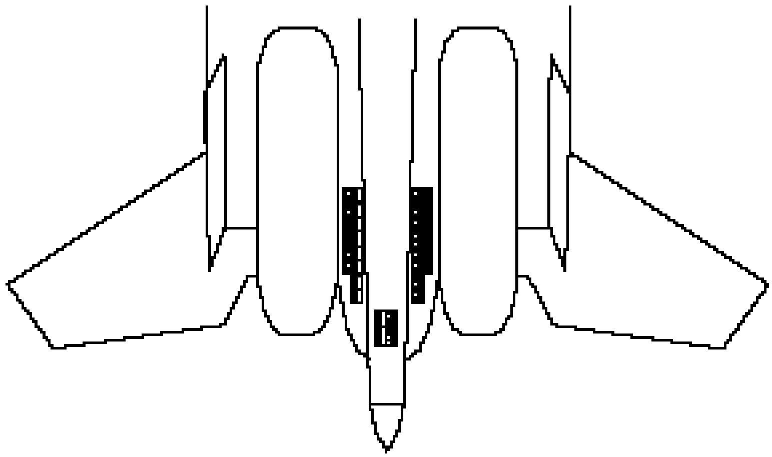
Deception countermeasures (DCM) involve generation of false targets and causing radars or IR seekers to lose the target. One of the earliest forms of deception DCM was chaff, generally large quantities of radar-reflecting material - narrow strips of glass fibre or nylon ribbon coated with metal. After being dispensed, chaff forms a cloud that reflects electromagnetic waves emitted by the enemy radar. This can break the lock on your aircraft or cause the missile radar seeker to relock onto the chaff cloud (see the figure below).



Chaff was used for the first time during WW II and showed itself as a cheap and sufficiently effective form of DCM. Effectiveness of DCM depends on the DCM resistance capabilities of the radar or missile seeker and on meteorological conditions (for example, strong wind may quickly disperse a chaff cloud). After being dispensed from a aircraft, chaff quickly decelerates, which leads to a significant difference in the speeds of the aircraft and the chaff cloud. This allows modern radars to recognise and ignore returns from the chaff cloud with relative ease.

Heated gases from the aircraft's jet engines (especially with the afterburners engaged) and the high temperatures in the combustion chambers provide reliable searching and tracking for IR-guided systems. The most widely used countermeasures against IR search and tracking equipment are decoy flares. Each flare is a small rocket that is fired upright and flies away from the aircraft to a distance of 100 metres or more (when fired on the ground). With a timely fired flare having intense heat point emission you may decoy the infrared guided missile launched at your aircraft. A decoy flare will burn only for a short time (about 10 seconds). It is recommended to dispense flares at a range of less than 10 km from the inbound missile when the IR emission of the flare is high enough for attracting the IR seeker. Simultaneously with flare deployment, you should make a break turn and cut the afterburners to avoid being locked again by the time the flares burn out. If you apply flares too early, the missile may ignore it or may have enough time to lock on your aircraft again when the flare has lost its effectiveness.

Unfortunately, modern missiles seekers can recognise flares decoys as well by analysing their intensity of emission and their rate of deceleration. So you must not put your trust in only passive countermeasures because you can only effectively fool the missile by using them together with active jamming and proper manoeuvring.



To increase survivability, the Flanker is fitted with 32 upward-firing APP-50 chaff/flare dispensers, which are located in the tail boom (see the figure above) and contain 96 chaff cartridges or flares. The dispensers are deployed by pressing the Q key. In so doing, two decoy flares and one chaff cartridge are released. Applying chaff and flares simultaneously eliminates the task of deciding which type of the missile has been launched at your aircraft, radar or infrared.

Part 2.
Mission Editor

Preface

Besides teaching you to fly the Su-27 and fight air and ground battles, the Flanker program may become for you a genuine discovery in an additional aspect. A special module - the Mission Editor - will give you the possibility to train as a tactician in the art of aerial warfare. While working with the standard missions coming with the program, you will plan combat tasks for both your own aircraft and a host of other objects controlled by the program such as aircraft, SAM systems, and ships. If, however, you come to flying the standard missions with one hand tied behind your back, do not fall in despair! You can create missions OF YOUR OWN and simulate practically any combat situation. You can take part in missions you have built as a pilot of the Su-27 or you can let the program stage a combat operation while you are contemplating the fortunes of war from the Olympian heights of your chair.

We have prepared many training and combat missions for the players who do not fancy strategic planning or have difficulties with it. These missions do not require any planning and you can run them straight away. However, even in this case you will need some knowledge of the Mission Editor because it is the shell of the entire program.

You will learn how to work with the map, plan combat tasks, analyse the course of events during a mission and create excellent video sequences. We will not teach you strategy because this problem is exceedingly complex and there is no single method for winning a war. Sometimes we will only suggest to you how to plan combat missions better. All the rest is in your hands.

Chapter 9. Theatre of play

Why Crimea?

The Flanker version you have bought introduces the Crimea as the theatre of play. For many centuries this small peninsula on the Black Sea has been a focus of interest, and its past and present political situation are the main reasons why we have chosen it as the combat zone. The geography of the Crimea is also well suited for flight simulation. Firstly, as a peninsula it has natural boundaries, secondly, the geographical characteristics of the Crimea - steppes, mountains, lakes, and sea ensure diversity and ease of orientation.

Fortunately, war has not touched this picturesque territory too recently. All you will see in the program and take part in is nothing more than fiction that, we hope, will never become reality. But who knows...

Geography

The Crimea is a peninsula in southern Ukraine with a surface area of 27 thousand square kilometres. In the south and west the peninsula is washed by the Black Sea and in the east - by the Sea of Azov.

In the north the Crimea is connected with the Kharkov Region by the Perekop isthmus. The Kerch strait connecting the Black Sea and the Sea of Azov separates the Crimea from Russia. Sivash - a series of shallow gulfs separated from the sea by a lowland sand spit - stretches along the whole of the north-eastern coast.

The northern part of the peninsula is a plain covered by steppe; the southern part is occupied by the Crimea Mountains that stretch from Sevastopol to Feodosia and consist of three parallel ridges with gentle northern and steep southern slopes. The highest point of the Crimea is the Roman-Kosh mountain (1545 metres) situated to the north-east of Yalta.

The Crimea is blessed with a Mediterranean climate. The rivers of the Crimea are shallow. It also has some large salt estuary lakes. The upper part of the peninsula has a system of canals.

The capital of the Crimea is Simferopol which has a population of 350,000. The main towns of the peninsula are Sevastopol, Kerch, Dzhankoy, Yalta, Yevpatoriya, and Feodosiya. The Crimea is the favourite recreation place of Russian and Ukraine leaders and heads of state. In 1991 during the coup initiated by the supporters of the communist regime Michael Gorbachev, the president of the late USSR, was blockaded at his dacha in Foros in the south extremity of the Crimea.

Historical background

The most ancient artefacts found in the Crimea date from the Palaeolithic period. A Scythian State arose in the steppe part of the Crimea in the third century BC. All subsequent history of the Crimea is a history of wars.

In the 3-4th centuries A.D. Goths and Huns seized the Crimea and founded the Tmutarakhan Principality. In the thirteenth century A.D. Mongol-Tatars invaded the peninsula and founded the Crimean Ulus of the Golden Horde. After the Golden Horde had collapsed in 1443, the Crimea Khanate arose and remained in existence for about 300 years as a vassal of Turkey. During all those centuries the Russians and Ukrainians fought side by side against the Tatar and Turkish raids.

As a result of the long war between Russia and Turkey the Crimea was made a part of Russia in 1783. During the "Crimean War" that lasted from 1853 to 1856 Russia waged war with Turkey, England and France and was badly defeated. But the peninsula remained in Russian hands.

The territory of the Crimea was also an arena of military operations during the Civil War in Russia (1918) and WW II (1941-1945). The Crimean Conference of the heads of 3 allied states - victors in WW II took place in Yalta in 1945. Josef Stalin represented Russia; Franklin Roosevelt represented the USA; and Winston Churchill represented Great Britain.

In 1954 Khruschev transferred the Crimean Region as a gift from Russia to the Ukraine. When the USSR collapsed and the Commonwealth of Independent States (CIS) was formed in 1991, the Crimea remained technically part of the Ukraine.

At present, the most acute problem that may result in an escalation from a political conflict to a military one is the problem of the Black Sea Fleet. The main reason of disagreement is the fact that after the collapse of the USSR both the Ukraine and Russia made claims to the Black Sea Fleet although historically the Fleet was always Russian. Furthermore, the main naval base of the Black Sea Fleet is Sevastopol and many other military installations of the late USSR on which Russia is making claims have turned out to be on the Ukrainian territory.

To solve the problem of the Black Sea Fleet, Russia carried out several rounds of negotiations with the Ukraine from April 1992 to May 1993. Finally, on June 9, 1995 the two countries signed an agreement, under which the Ukraine recognised Sevastopol as a naval base of the Russian Black Sea Fleet. Furthermore, Russia received 81.7% and the Ukraine got 18.3% of the ships and vessels of the Black Sea Fleet. However, the agreement did not decide the legal status and the conditions of stay of the Russian Black Sea Fleet in the Crimea.

The process of negotiations between Russia and Ukraine is being further complicated by general political tension in the peninsula. The Russians making up the majority of the Crimean population are striving for independence from the Ukraine and for reunification with Russia. The population of the Crimea has formed its own government actively opposing the politics of the Ukraine. The overwhelming majority of the population is striving to get Russian citizenship. Conflicts on inter-ethnical grounds have arisen between the Russians, Ukrainians, and Tatars forcing Kiev to bring in special units from the Ministry for Internal Affairs.

In March 1995 the Ukrainian Parliament abolished the institution of presidency and the Constitution of the Crimean Republic that resulted in recurrent aggravation of the political situation in this region.

What next?

The subsequent development of events in the Crimea is going on according to the following scenario.

In the autumn of 1995 the Crimean Republic holds a referendum on the independence of the Crimea contrary to the decision of the Ukrainian Parliament. To ensure the territorial integrity of the Ukraine, the Ukrainian authorities make a decision to send regular forces into the Crimea. The special units of the Ukrainian militia break up spontaneous meetings and carry out mass arrests of the most active supporters of the independence. To ensure the security of its military installations and naval bases, Russia places all its forces in the peninsula in advanced combat readiness. A Russian naval landing force seizes a part of the military airfields. Transport aircraft transfer additional naval, airborne, and air units and military equipment. Trying to counteract Russian troops, Ukrainian Air Defence units shoot down near Kerch a Russian IL-76 transport aircraft carrying paratroopers. In response to this, two Tu-22M3 bombers escorted by Su-27 fighters carry out a missile and bomb strike on the positions of the Ukrainian Air Defence and destroy two Kub SAM systems and an Early Warning Radar station.

The local conflict that has arisen is fraught with complications. At an emergency meeting of the UN Security Council the members decide to send an observation mission of NATO ships and aircraft to the conflict area. But while the politicians are trying to settle the conflict, the military solve the problem by other means . . .

In this situation we leave you alone with the Flanker simulator. You can take part in the hostilities on either the Russian or Ukrainian sides as both an ordinary pilot and a general on whose military wisdom depends the general success of the operation and general situation in the region. Anyway, your task will be the strict adherence to a mission that has been set for you whether it is an intercept of an enemy aircraft or area defence. You are forbidden to destroy civil ground installations not included in your mission plan, as it may cause victims among a peaceful population and the protests of the world community. Furthermore, in no circumstances should you attack aircraft of neutral forces - otherwise you are at risk of aggravating an already complex international situation.

We wish you victory!

Chapter 10.
Getting Started

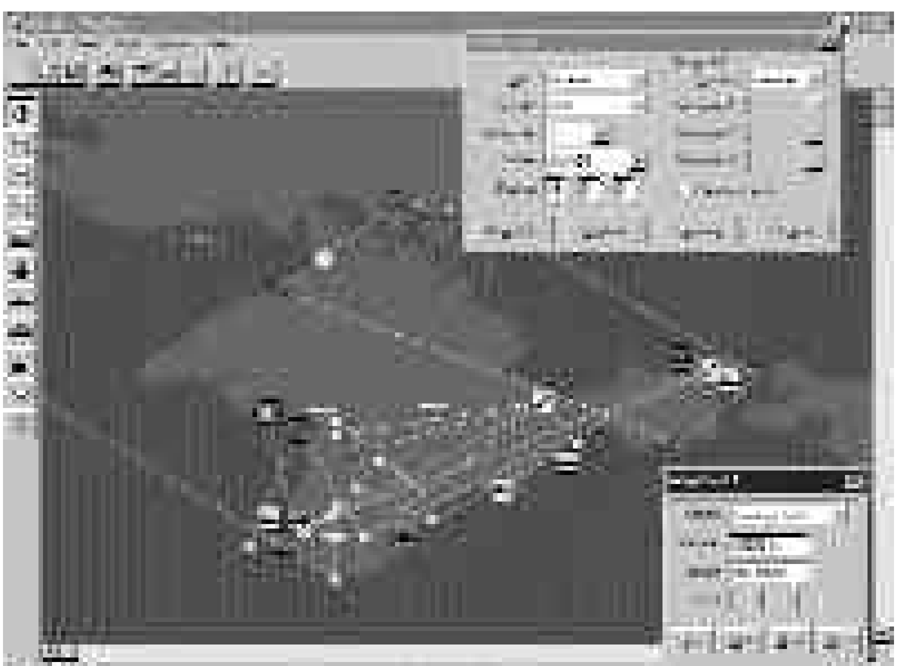
By the term mission we denote a combat operation or a training flight intended for performing a specific combat or training task, for example, an intercept, suppression of air defence installations, escort, close air support, and so on. Some missions are ready for flying, whereas other missions require preparatory planning.

Depending on the resources that you will have at your disposal, all missions fall into classes, which we discuss in detail in Chapter 11, "Planning your mission". Here you will learn the features of the Mission Editor, methods for working with the map, and how to fly training missions before you risk flying a real combat mission.

At First Glance

If you have not yet installed the program or do not know how to run it, we suggest that you refer to the separate Technical Supplement, which describes how to install and run this software for different hardware and operational environments (Windows 95, or DOS).

On starting the program, you find yourself in the Mission Editor representing the shell for the entire Flanker program. If you have not specified any mission name in the command line the screen will show a map of the Crimea with only airfield symbols on it. Here is the Mission Editor with a typical mission opened.



Menus

The top line of the program window contains the Menu Bar. From here you can execute most of the Mission Editor commands. There is a pull-down menu hidden under each menu heading. These are **File, Edit, View, Flight, Options** and **Help.**

The following table contains all of the menu commands:

Menu	Menu item	Meaning
File	**New Mission**	Create a new mission
	Open Mission	Open an existing mission
	Save Mission	Save the active mission to disk
	Save As	Save the mission under another name
	Print	Print the current map, briefing or debriefing
	Program Setup	Configure your supplementary hardware and set up program preferences
	Exit	Quit the program
Edit	**Undo**	Undo the last editing change
	Restore Mission	Undo all the changes to the mission since the last save
	Classify Mission	Assign the active mission to a class and protect it with a password
	Declassify Mission	Declassify the active mission to have access to all mission resources; password will be required
	Delete	Delete the current selection on the map
	Properties	Edit properties of the current selection
View	**Pan**	Shift the map in the specified direction
	100%	Show the entire theatre of play
	Zoom In	Magnify the map by a factor of 2 or in the dragged box
	Zoom Out	Scale the map down by a factor of 2
	Previous Scale	Restore the previous map scale
	Show Grid	Toggle the scale grid
	Standard Toolbar	Toggle the Standard Toolbar
	Planning Toolbar	Toggle the Planning Toolbar
	Show Status Bar	Toggle the Status Bar

Menu	Menu item	Meaning
	Preview Object	View 3D models of objects
	Hide Objects	Hide or show specific objects on the map
Flight	**Briefing**	View/edit the mission briefing
	Start	Start the current mission
	Record	Start the mission and record a video sequence
	Play	Playback the last recorded video sequence
	Video Edit	Start the video sequence and enable its editing
	Debriefing	Display the mission debriefing and statistics
Options	**Failures**	Specify failures that may happen to your aircraft for training purposes
	Skills and Survivability	Set skill levels for all automatic objects; specify your aircraft's survivability
	Met Report	Specify meteorological conditions (wind, temperature, cloudiness, etc.) for the active mission
Help	**On-line Manual**	Look through the on-line book on the Flanker (Windows® 95 only)
	Video	Show video footage on the Flanker
	About Su-27 Flanker	Show the program info, version number and copyright notice

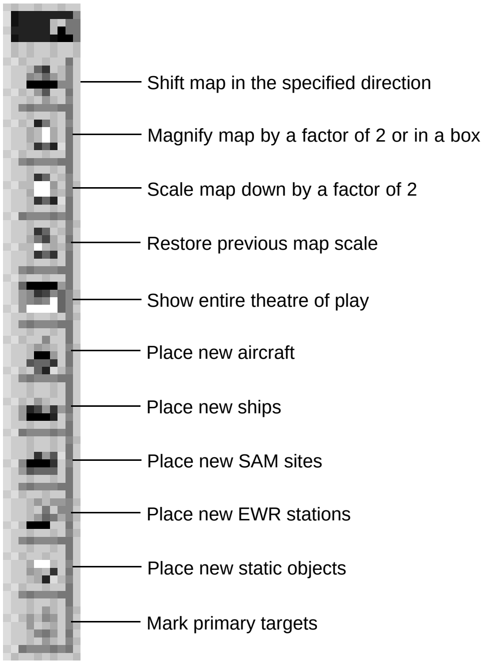
Buttons

Beneath the Menu Bar is the Standard Toolbar, which contains a set of standard buttons, typical to many windows applications.

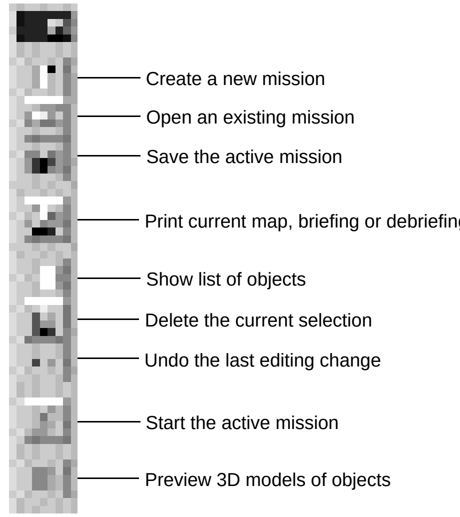
The Planning Toolbar down the left-hand side will be your constant assistant while you are planning combat tasks. It contains buttons for scaling the map, placing aircraft, ships, SAMs, radars, and other objects.

The buttons provide you with quick pictorial access to the Mission Editor commands, many of which are duplicated in the menus. Note that you can move the toolbars to wherever you see fit.

Planning Toolbar



Standard Toolbar



Along the bottom of the program window runs the Status Bar, which shows information on the Mission Editor mode, the current geographical coordinates of the mouse pointer, and a short help line on the selected Toolbar button or menu command. Down the right-hand side and across the bottom of the screen are two scrollbars providing the scroll of the map.

Working With the Map

When working in the Mission Editor, you will be required to intensively use the map for identifying targets, planning routes and placing objects. While using the map, you can:

- scroll the map in any direction
- zoom the map on the screen in or out
- show the coordinate grid.

Panning

If you are interested in a particular area, which is beyond what's on screen you can shift the map in the desired direction. We recommend that you use the scrollbars for coarse scrolling and the Rubber Line for precise adjustments.

To pan the map in a specific direction

1. Click on the Pan button on the Planning toolbar.
2. Press and hold down the left mouse button anywhere on the map. Make sure that the cursor isn't on an active object, otherwise that object will move.
3. Drag the mouse pointer in the desired direction for the required distance. The direction of the movement will be shown on the map by the Rubber Line.
4. Release the button. The area of the map you see on the screen will scroll in the direction and for the length of the Rubber Line.

To scroll the map vertically or horizontally

Do one of the following:

- Drag the scrollbox along the scrollbar in the desired direction
- Click the corresponding scrollbar arrow repeatedly;
- Click anywhere in the grey area on the scrollbar next to the scrollbox.

In all these cases the map will scroll in discrete steps. The minimum length, by which the map can be scrolled is equal to 1/4 of the current width or height of the map area you see on the screen. Naturally, the smaller the scale of the map, the greater the real distance over which you can move.

Zooming

If you are interested in details of a given area on the map or want to have a look at the entire theatre of play, change the map scale by zooming in or out.

To zoom in

1. Click on the Zoom In button on the Planning Toolbar or press the **Grey_+** key on the keypad.
2. Do one of the following:
    - To scale the map up by a factor of two, click the left mouse button in the centre of the map area you want to enlarge.
    - To enlarge a given area to the size of the map window, select a rectangular region on the map by pressing the left mouse button to anchor one corner of the area and then dragging the mouse pointer. The stretching Rubber Rectangle shows the region being selected. Release the mouse button to complete zooming.

Note that Zoom In mode remains active until disabled, so you can apply zooming in repeatedly. To disable, "unpress" the Zoom In button, click on it with the mouse or click the right mouse button anywhere on the map.

To zoom out by a factor of 2

- Click on the Zoom Out button, or press the **Grey_-** key.

To view the entire theatre of play

- Click on the 100% button or press **Ctrl+1**.

Note that you cannot zoom out beyond the 100% scale.

To restore the previous map scale

- Click the Previous Scale button or press **Ctrl+BackSpace**.

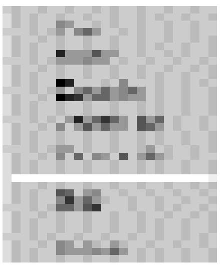
You can apply this command repeatedly to restore any map scale applied in the current session.

Displaying the co-ordinate grid

The coordinate grid makes life easy when planning missions. It will help identify targets, place active objects and design routes in terms of longitudes and latitudes. Note that as you zoom in or out, the mesh changes to display the same meridians and parallels in any scale.

To toggle the coordinate grid, select **View, Show Grid**, or press **Ctrl+G**.

Note. Many commands for working with the map are available through *shortcut menus*, which you activate by clicking the right mouse button in any place on the map free from active objects.

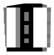
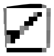
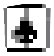
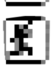


Working with Objects

When planning existing missions or building new ones, you will be placing aircraft, ships, SAM systems, possibly passive objects and designing aircraft routes. In our terminology, all the above are objects. Some of them are active objects (ships, aircraft, radars, SAM systems), whereas other objects are passive or static (automobiles, tanks, fuel trucks...). Active objects have particular levels of artificial intelligence and behaviour; they are marked by an individual symbol irrespective of the current map scale. You can place static objects in an arbitrary or specific way. For example, increasing the number of aircraft parked on an airfield makes it a more interesting ground target.

A special case is a SAM system, which consist of several units operating as a functional entity. For example, a standard S-300PMU Grumble system consists of one surveillance radar, one engagement radar and up to 6 launchers, each of them on a separate chassis. In similar cases all units comprising a system are marked by individual symbols on the map.

The table below contains a list of all symbols used on the map.

	airfield
	take-off waypoint
	landing waypoint
	Ground Alert Intercept station. This is the only waypoint of the GAI sortie
	turning point of an unselected route. Such a waypoint is always displayed in the colour of the country owning the aircraft
	turning point of the selected route. The number indicates the waypoint's ordinal number (from 0 to 15).
	action point of an unselected route. An action point implies a particular action associated with this waypoint (rocket attack point, start of a CAP station)
	action point of the selected route. The number indicates the waypoint order number.
	ship
	Early Warning Radar station
	surveillance radar of a SAM system
	engagement radar of a SAM system
	SAM launcher
	AAA or SAM system housing both radar and launcher/guns
	portable SAM launcher (Igla)
	static object
	primary target

When working with objects on the map you can:

- Select a single object or a group of objects;
- Move or delete a group of objects;
- Fix objects in their places to protect them from an accidental move or edit;
- Hide or show objects;
- Preview a 3D model of any active object in the simulation;
- Undo editing changes.

Note, however, that the Mission Editor is not a graphical editor as it may seem to be. That is why some features typical to a graphical editor may be different in the Mission Editor or not implemented at all.

Selecting objects

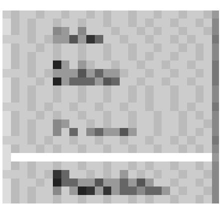
To select objects on the map, you should first make sure that none of the special map modes (zooming, panning) and the modes for placing new objects are active. This will be witnessed by the absence of sunken buttons on the Planning Toolbar.

To select an individual object, click it with the left mouse button. The selected object will be highlighted by the selection colour (by default, yellow), and the corresponding dialog box describing the object's properties (for example, a country to which it belongs, object type, orientation, skill level, and so on) will appear on screen.

To select an aircraft and its route, click on any of its waypoints. This will display the Waypoints dialog box which is (described in Chapter 11, "Planning your mission". In so doing, all the waypoints enlarge and display their ordinal number on the route (from 0 to 15). Furthermore, the current waypoint and the legs of the selected route turn to yellow.

If you want to view the properties of the aircraft, double-click on any of its waypoints or press the properties button on the Standard toolbar or press the **Alt+Enter** keys, or select **Properties** from the object's shortcut menu.

You can also select any object by clicking it with the right mouse button. By doing so, you invoke a shortcut menu, which lists operations available for the object. A typical shortcut menu is shown below.



While planning a mission, you might want to move a group of objects the same distance or delete them. To include an object into a group, click it while holding down the **Shift** key.

If you need to unselect an individual object, click the left mouse button anywhere on the map off objects or select another object. To exclude an object from a group, apply the Undo command as described below in this chapter.

Moving and deleting objects

To move a single object or a group of selected objects, place the mouse pointer on this object or any object in the group, hold down the left mouse button and drag the object or the entire group to the new place on the map. Then release the button.

To delete a selected object/group of objects, click the Delete button on the Standard Toolbar, or press **Del**. When you delete waypoints, the remaining waypoints of the route will be automatically renumbered.

Hiding objects

If you think that the map shows too many symbols of objects, making it difficult to plan a mission or understand a combat situation, you can temporarily hide those symbols which are of no interest to you at that moment. You can do this with an individually selected object or a group of objects or you can use a specially formulated criterion, for example, hide all enemy ships.

To hide an individual object or a group of selected objects choose **Hide** from the shortcut menu. The symbols of the selected objects will disappear from the map together with the objects they label. Note, that if you try to hide any waypoint of a route, this leads to hiding the entire route.

Activate the **Hide Object** dialog box from the **View** menu or by pressing **Ctrl+H**. Hide objects by unchecking the object type, and show them by checking.

Use the **Side** field for selecting the side whose objects you want to hide or show, for example, Russia or Ukraine. You can also click the **Show All** button or **Hide All** button. If none of the objects of a particular type is available on the map for the selected side, the corresponding check boxes will be greyed.

Note. You can hide or show air defence areas and SAM threat zones, which are displayed as hatched areas on the map. An air defence area covers the maximum detection range of the Early Warning Radar or SAM radar. Note that the radar itself may be hidden.

If you want to hide a specific ship, aircraft, or other active object, point to the object and click the right button. This will activate the shortcut menu; select **Hide**.

Note that you will not be able to see those objects that take part in the mission which are not available to you, for example, enemy aircraft.

Previewing objects

If you want to have a look at a 3D model of a particular object and to get a description of its main specifications, select the object on the map and click the Encyclopedia button on the Standard toolbar or select **Preview** from the object's shortcut menu or press **Ctrl+E**.

If necessary, you can preview practically any placeble object used in our simulation, active or passive. To do this, specify a class to which the object belongs (for example ship, aircraft or missile) and the object’s type, for example, S-300 launcher or Su-25).

The dialog box will display a 3D model of the object, which you can rotate in a number of directions using special buttons at the bottom of the dialog box. Using the Play and Stop buttons you can control automatic rotation of the object about its vertical axis.

Information about the main specifications of the object are shown in the scrollable text box at the left.

Undoing changes

If you need to undo the last action such as selecting, moving or deleting a single object or a group of objects as well as changing object properties, click on the Undo button on the Standard Toolbar or select **Edit, Undo** from the menu (press **Ctrl+Z**).

You can undo as many changes to objects as you need because the Mission Editor stores records about all changes made in the current session. However, if you need to undo a lot of changes, it is sometimes more convenient to restore the mission to the state in which it was at the moment of the last save. To do this, select **Edit, Restore Mission**. All the changes, including those made to the entire mission (meteorological conditions, skills, failures), will be undone.

In Flight and Combat Training

Before you start flying combat missions, we strongly recommend that you master piloting in the Su-27, its instrumentation and weapons. To help you master the Flanker quickly and effectively, we created a series of demonstration and training missions. They will provide assistance in everything - from learning how to take-off and land to air combat and ground attack.

Demo missions and training missions are similar to a large extent and have only the following distinctions. A demo mission shows you how to correctly execute a manoeuvre or how to employ a specific weapon. At any moment you can repeat the action being shown by interrupting the demo clip by pressing the **Esc** key and taking over control. Training missions do not show any demonstrations. They imply that you will train using your own discretion. However, unlike demo missions, which are cut and dried, training missions allow you to complicate the task or make it easier. When mastering a training flight or training combat, you can set specific weather and the time of day, simulate failures of the onboard equipment and specify the enemy's skill level. (Unfortunately, you cannot do this in the combat missions we have prepared.)

Demo missions

One of the assets of the demo missions lies in the fact that they are created in cooperation with experienced fighter pilots and show you how to correctly perform various manoeuvres and aerobatics routines and employ weapons. However, their main value is that we in effect demonstrate to you not only an animation clip, which was put together from specially selected frames, but the real course of events, in other words, the mission is played in real time but as if on your behalf. You have a possibility of analysing the flight during a demo mission by switching to the Cockpit View and to many external views. In so doing, you can change the directions in which the pilot looks from the cockpit or the location of the external view point and the distance to it. You will have at your disposal all the information, which will be shown on the flight instruments and in the Status Line at the bottom of the screen. The Status Line is displayed in external views and shows the name of the object being viewed, its heading, airspeed, altitude, and rate of climb/dive. But the most important thing is that at any moment during the demonstration you can take over the control by pressing the **Esc** key and continue the flight on your own.

We should mention that you will have a possibility of creating your own demo clips. We describe this in Chapter 13, "Miscellaneous".

Which demo mission to choose for studying depends on your piloting skill and combat training. We recommend that you always proceed from simple tasks to difficult ones. First, for example, you can master take-off, free flight and landing both individually and as a whole. After that you can move on to aerobatics and, finally, to combat missions for mastering air combat and air-to-ground attacks.

To load a demo mission into the Mission Editor, select **File, Open Mission**. Choose "Demo mission" as the file type and select the desired mission from the list. The mission title and the text describing the mission appear to the left. You can use the scrollbars in the Info box to view invisible parts of text.

After you have selected a mission, you can start it immediately by pressing the **Run** button. If you first want to familiarise yourself with the disposition of forces and the terrain map, load the mission into the Mission Editor by pressing the **Open** button. After having a look at the map you can start the mission by pressing the Start button on the Standard toolbar or by selecting **Flight, Start** from the menu bar.

Note that when you load a demo mission into the Mission Editor, you will not be able to make any changes, be it changing the locations of objects including your aircraft or changing weather conditions. If you want to learn fly in different meteorological conditions, practice system failures, from various airfields and so on then just read on.

Training missions

Training missions provide you with the possibility of facilitating or complicating a task when you train in piloting and air combat. You will be able to plan a route using your own discretion and change your weapons load. Furthermore, you will have the possibility of changing certain parameters, which are beyond your reach in prepared combat missions. Among other things you can:

- Set specific meteorological conditions (cloudiness, wind, atmospheric turbulence, etc.) and the time of day. Practice flying (especially landing) in bad weather and at night. This will really sharpen your concentration skills.
- Have the program imitate onboard systems failures (engines, radar, autopilot, etc.). Having to return to base on one engine or with hydraulic failure is very typical in combat.
- Specify skill levels for enemy and allied forces.
- Specify combat survivability for your aircraft.

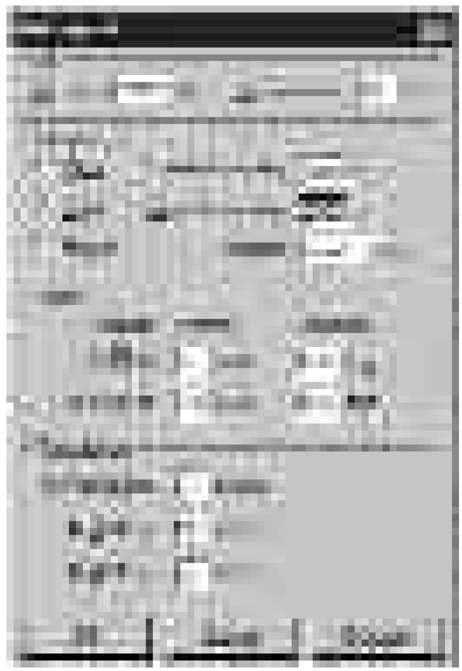
To load a training mission, select **File, Open Mission** and specify "Training mission" as a file type. (Note that both training and combat missions have the '.mis' file extension).

We suggest that you start a training mission after familiarising yourself with the mission objectives, the mission situation and, possibly, changing some parameters using your own discretion. It is best to begin studying a training mission from the briefing (select **Flight, Briefing**). The mission start time in the Briefing dialog box can be changed, if necessary.

As a rule, your route in training missions will already be pre-set. However, you are allowed to make any changes to it. To learn how to plan routes and to load weapons and fuel, refer to Chapter 11, "Planning your mission".

After you have prepared a training mission, save it to disk. To do this, select **File, Save As** and enter some new file name lest the initial mission, to which you will possibly want to return later, be erased. In so doing, you can omit the file extension as the Mission Editor adds '.mis' automatically. You can edit the mission title in the **Title** field. Complete the operation by pressing the **Save** button.

To launch a training mission, select **Flight, Start**.



Changing meteorological conditions

To try out piloting in various meteorological conditions, you can specify several parameters which affect the behaviour of your aircraft and visibility in both the visible and the infrared regions of the spectrum.

You specify meteorological conditions in the **Met Report** dialog box which can be opened from the **Option** menu. They can be changed only in training missions or while creating new missions. You fly combat missions at pre-set meteorological conditions.

Temperature

Ambient temperature affects engine thrust. The lower the temperature the higher the thrust and therefore the aircraft's speed. Furthermore, fuel consumption in cold weather lowers.

The temperature you specify will correspond to the ambient temperature at sea level. Ambient temperature decreases with altitude. You should specify temperature in degrees Celsius. Allowable temperatures in our simulation range from -20°C (-4°F) to +35°C (95°F). Standard day temperature is +20°C.

Pressure

Atmospheric pressure, like ambient temperature, influences the aerodynamic properties of aircraft. Thus, for example, the lower the pressure, the less the air density. This means that aircraft require more true airspeed/AOA to stay airborne, therefore, require additional thrust. All this results in increasing fuel consumption, all other factors being equal.

You can specify the atmospheric pressure at sea level in the range from 867 mb (650 mm Hg) to 1067 mb (800 mm Hg). Standard day pressure is 1013.2 mb (760 mm Hg).

Cloudiness

Cloudiness mainly affects optical visibility. In addition, clouds may degrade the performance of guided missiles employing passive IR homing. Thus, cloud layers scatter infrared energy and might interfere with locking onto the target of the missile's seeker or might lead to breaking the lock during the missile's flight.

You can specify the intensity of cloudiness (light or heavy) and its lower and upper boundaries. In our sim, clouds cannot lie lower than 100 metres and higher than 4000 metres. The visibility parameter specifies the maximum distance at which you will be able to visually spot flying aircraft irrespective of size.

Wind

Wind seems to have the most effect on landings (see Chapter 3, "Piloting the Flanker" on how to land the Flanker in crosswind). You can specify the wind speed (km/h) and its direction at two characteristic altitudes: 50 metres and 1000 metres. The maximum permissible values are 54 km/h and 100 km/h, respectively.

Turbulence

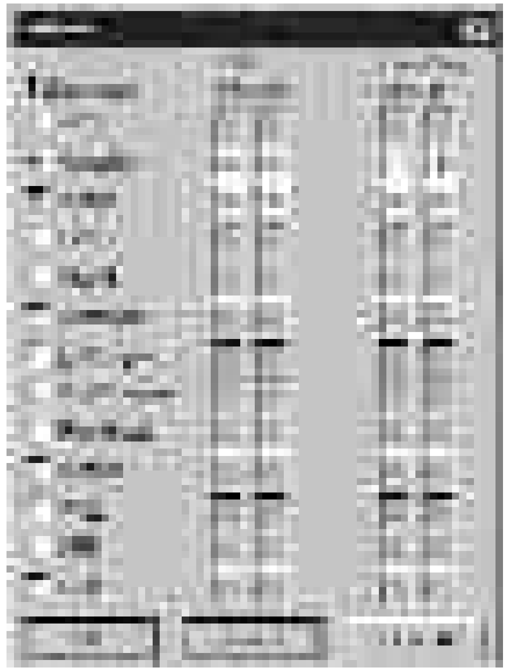
Atmospheric turbulence is the movement of downgoing and upgoing airstreams causing bumps. The main reasons for turbulence have to do with the friction of airstreams on the ground surface, non-uniform heating of ground, the collision of atmospheric fronts having different temperatures, speeds and directions of movement, and of course rising terrain. Turbulence may lead to reducing flight speed, inaccurate readings of flight instruments, low-amplitude jolting and shaking of the aircraft at high airspeeds. As this takes place, the G-load may change chaotically with dispersion of values that may sometimes be as much as ±2 Gs during strong bumps.

You can specify turbulence by entering the wind speed (m/s) for three characteristic areas - in the mountains and at altitudes of 2000 metres and 8000 metres. The strongest turbulence in mountains occurs on the lee slopes.

Imitating system failures

Your aircraft might be damaged in combat as the result of a missile or shell hit. To be ready for such a situation and to be able to fly the aircraft onboard systems failed, the program allows you to imitate emergencies.

Select **Options, Failures** and specify in the dialog box the failures which the program should imitate. Specify the exact failure time for the particular failure you wish to practice or a time between failure (TBF) if you wish to simulate failures without exact failure times but which will occur for sure within that specified time. For example, if you specify 00:30 in the **TBF** field for the radar this means that your Zhuk-27 will fail for sure within the next 30 minutes. If you were to specify 11:30 in the **Exact time** field you can be sure that exactly 11 mins 30 sec after takeoff the failure will occur. If you specify an exact failure time it will have priority over the TBF setting.



ACS

A failure of the Automatic Control System (ACS) will cause the Flanker's flight control system to switch to "proportional control mode" in which a control signal from the stick delivers proportional movement of elevator. However, in this situation the aircraft still benefits from a particular degree of stability augmentation unlike in direct link mode when doing a Cobra manoeuvre. If the ACS failed to operate, very smooth stick movement is required to avoid large angles of attack and G-loads.

Autopilot

A failure of the autopilot leads to the aircraft's inability to automatically follow the pre-set route or keep a given altitude in the Altitude Stabilisation mode.

Radar

If the radar fails, this denies your aircraft the ability to actively search using the Zhuk-27 radar though you still have the EOS at your disposal.

EOS

A failure of the Electro-Optical System denies your aircraft the ability to passively search for enemies.

MLWS

If the Missile Launch Warning System fails, you will not be able to receive warnings about missiles launched in your direction.

Hydraulics

A failure of the hydraulic system degrades control of your aircraft and can make it uncontrollable.

Engines

If one engine fails, you can still continue flight (see Chapter 3, "Piloting the Flanker" on how to fly your jet with one engine out). If both engines fail at a stone's throw away from an allied airfield, you might try to land your aircraft, otherwise, eject!

Pitot head

A failure of the pitot head causes incorrect instrument readings of your airspeed and altitude. Note that the Su-27 has three pitot heads ensuring high redundancy and precision.

Helmet

When the Helmet Mounted Target Designator (HMTD) fails you cannot use Helmet mode.

HUD

If the Head Up Display fails, its screen blanks. You still have the option of flying on instruments.

MFD

When the Multi Function Display fails, its screen blanks.

ECM

If the ECM system is damaged, you cannot employ active jamming using the onboard ECM system equipment and/or the Sorbtsiya external ECM system.

Specifying skills and survivability

When flying training missions you have the possibility of changing skill levels for all active objects at once. This may prove useful if you find it difficult to oppose a strong enemy or, alternatively, you feel that your enemy is too weak.

You can also change the combat survivability of your aircraft. The combat survivability is the aircraft's ability to withstand weapons used against it. The higher the survivability the less the possibility of your aircraft being damaged by missiles or cannon shells. In terms of the game programs, it is as though you get additional lives.

To specify the parameters under consideration, select **Options, Skills and Survivability**.

Specify the minimum and maximum allowable skill levels for all active objects (enemy, allied, and neutral) in the mission. You can choose skills from Average, Good, High, and Excellent. For example, if you specify Good in the **Min** field and High in the **Max** field, all aircraft, ships, etc., which had skill levels below Good will change to Good. And all the remaining objects (having the High or Excellent skill levels) will get the High skill level.

Note that the minimum skill level must not exceed the maximum one.

We provided four levels for the survivability of your aircraft: Moderate, Normal, Good and High. In the beginning you most likely will choose High. Note, however, that even this survivability level does not guarantee you immortality.

If you have problems with landing, enable the **Allow Hard Landing** check box. If you do this, the Flanker will forgive you many errors associated with hard touch downs.

Manipulating Views

The Flanker program provides you with a bunch of views. You can observe the course of events from the cockpit of your Su-27, from a fixed point on the ground, or from some point in the air. In addition, you have an option to watch AAA, SAM systems, and ships. In so doing, you can arbitrarily change the aspect angle and the distance to the object being viewed. The right choice of views will help you during your analysis of the demo missions and will make your video sequences exceedingly spectacular.

The table below lists all the views you can use in the simulation.

Key	View
F1	Cockpit View; applicable only to your Flanker
F2	Outside View. A view of the current aircraft from some remote point which moves along with the object
F3	Tower View. A view of your aircraft from the tower of the nearest airfield or from some ground-based observation post. If your aircraft is further than 5 km away from an airfield, this view will put you in a head on swivel camera track position. Very spectacular.
F4	Ground View. A view of the current AAA, SAM, or EWR station.
F5	Outside+ View. It is similar to the Outside View with the only difference that if the aircraft being viewed launches a missile or releases a bomb, the given view automatically switches to that weapon. When the weapon is destroyed on hitting the target or when self-destructing, the view automatically returns to the aircraft viewed last.
F6	Chase View. A view of the current flying object (aircraft, guided missile, or bomb) from an imaginary chase plane.
F7	Chase+ View. It is similar to the Chase View with the only difference that if the aircraft being chased launches a missile or releases a bomb, the given view automatically switches to chase that weapon. When the weapon is destroyed on hitting the target or when self-destructing, the view automatically returns to the aircraft viewed last.
F8	Ship View. A view of the current ship from a particular remote point.

When you are working with all of the above views except the Cockpit View, pressing the function key repeatedly will cycle through all active objects of the corresponding type (airborne, ground, naval). For example, by repeatedly pressing the **F2** key, you will cycle in Outside View through the aircraft currently airborne. In so doing, the cycling order of objects depends on the times of their active appearance in the mission.

When you need to quickly switch to view the last activated airborne object, press the respective function key while holding down **Ctrl**. For example, to chase the aircraft, missile or bomb that appeared in the mission last, press **Ctrl+F6**.

In all external views related to airborne objects you can quickly switch to your Flanker by pressing the **NumLock** key.

Control the view point of the object being observed for all of the above views by using the keypad.

Cockpit View

The table below lists all available views from the cockpit of your Su-27.

Key	Meaning
KP_1	Look left and down
KP_2	Look up
KP_3	Look right and down
KP_4	Look left
KP_5	Look forward
KP_6	Look right
KP_7	Look left and up
KP_8	Look down
KP_9	Look right and up

You can use the coolie hat of your joystick, if any, to shift the direction of your glance in all navigation and combat modes except BVR and A2G. Notice that by moving the coolie hat back you raise your glance and by pushing it forward you lower your glance, which is similar to the pitch control of your aircraft with the stick. You look left or right by moving the coolie hat to the respective side. You should also be aware that in some combat modes (Beyond Visual Range, Longitudinal Missile Aiming and Air2Ground) the coolie hat controls the scan area of the radar, EOS, or the missile's seeker rather than the direction of your glance.

Track mode

When viewing from the cockpit you can press **Grey_*** to activate Track mode (padlock view). In this mode the nearest enemy aircraft will be automatically tracked and placed in the centre of the screen. Your aim should be to manoeuvre so that the HUD is positioned straight towards the enemy aircraft. If the latter is manoeuvring so that you cannot see it from the cockpit, automatic tracking will resume as soon as the aircraft comes back into view. But should the tracking aircraft not reappear within your maximum range of head movement (120∞ left, 120∞ right, 90∞ up) within 5 seconds then the Track mode is deactivated.

External Views

If one of the external views is active, you can control the location of the view point with the following keys:

Key	Meaning
KP_2	Move the view point down
KP_4	Move the view point left
KP_5	Place the viewpoint aft of the object being viewed on its longitudinal axis (the Chase and Chase+ Views only)
KP_6	Move the view point right
KP_8	Move the view point up
Grey_*	Approach the object
Grey_/	Move away from the object
KP_1	Move the view point towards the ship's bow (Ship View)
KP_7	Move the view point towards the ship's stern (Ship View)
KP_3	Move the view point towards the ship's waterline (Ship View)
KP_9	Move the view point towards the ship's mast top (Ship View)

Note that while in the Tower View, you can only come closer to your aircraft or move away from it.

In the Ship View you can additionally move the view point along the ship's side from the bow to the stern and from the waterline to the top of the mast. It may be convenient when you want to have a close look at the ship because of its significant length.

Chapter 11. Planning Your Mission

Introduction

After you have had a good look at demonstration flights and have learnt how to fly training missions, you're ready for more - taking part in a real combat mission. Here we strongly recommend that you begin from flying simple missions and then gradually step up to more difficult ones.

By the degree of planning complexity all available missions fall into three classes: Pilot missions, Squadron Leader missions, and General missions. Missions falling into the same class can differ in difficulty. For example, in one case you could be flying a combat air patrol (CAP) and see little action, whereas in another case you should penetrate enemy territory through its radar coverage, destroy SAM sites and sweat blood!

If, however, you want to create a mission from beginning to end fully using the resources of all sides taking part in the hostilities, you will find all necessary information in Chapter 12, "Building new missions". However, we suggest that you familiarise yourself with the information in the given chapter before tackling such a serious task, as this very chapter describes the main methods of planning.

Note that the current version of the program does not allow you to create campaigns lasting more than one day: all missions should be completed in one session. That is, you cannot interrupt a mission in its progress with the intent of resuming it later from the current point and in the same tactical situation. If you abort the mission, all returns to the initial state.

Normally, the process of mission planning and execution includes the following steps:

1. Loading a mission of a certain class into the Mission Editor
2. Familiarisation with the mission objectives
3. Depending on the class of mission and resources available: planning combat tasks for all the objects that should take part in the mission (aircraft, EWR stations, SAM systems, and ships)
4. Flying the mission on your own or performing in automatic mode
5. Debriefing and mission analysis.

Mission Classes

All mission classes differ from one another by the number and type of resources you will have at your disposal and, hence, by the amount of work involved. The Flanker offers you three combat mission classes:

- Pilot mission
- Squadron leader mission
- General mission

In addition, the program has provision for *Head-To-Head* missions and will be discussed in Chapter 13, "Miscellaneous".

In our simulation you can plan and perform several versions of the same mission to compare the results and find the optimal solution.

For any given mission you get information about your enemy mostly during mission briefing. On the map you either will not see enemy objects at all, or you will only find those that have been established through intelligence sources.

Potential threat zones related to enemy AAA, SAM systems and ships are shown on the map as crosshatched areas, however, the objects themselves may be concealed. Naturally, you should plan missions allowing for these threat zones. However, note that such a zone represents the maximum engagement envelope of the corresponding enemy weapon and does not consider terrain masking or aircraft's altitude and speed. This means that carefully planned routes allow aircraft to successfully fly even in threat zones.

Pilot mission

Here the combat task is usually formulated very particularly, for example, strike a particular ground target or intercept an enemy fighter. We recommend that you begin mastering the Mission Editor from the Pilot mission class as it is the simplest.

The pre-set flightplan, weapons and fuel load of your aircraft are typical for a Pilot mission. As a pilot, all you can do in the Mission Editor is familiarise yourself with the flightplan on the map. You can neither change your flightplan, weapons load and fuel load, nor add new objects to the battlefield. All you should do is fly your mission strictly following the pre-set flightplan. The main criteria that the program will use for evaluating the success of your sortie are the achievement of the mission objectives, total flying time, the number of destroyed enemy aircraft, and the type and quantity of the weapons employed.

Note, that while being just a pilot you generally cannot influence the outcome of the entire mission where other allied aircraft, ships, and SAM systems can also take part. However, in our sim the success of any pilot mission is evaluated only by your own combat actions. The detailed debriefing of your sortie showing all the events that occurred during the mission will be made in the Debriefing dialog box.

Squadron leader mission

The *Squadron leader mission* class gives you more leeway in deciding how to achieve the mission objectives than a junior pilot. A squadron leader can select the number of aircraft he will need (up to four), the skill of his wingmen, and the aircraft ordnance. He designs a flightplan for his wing and designates action points. In flight, the squadron leader can give orders to his wingmen, such as:

- Attack my airborne target (the **[** key)
- Cover my six (the **]** key)
- Toggle tight/loose formation (**Ins**)
- Join up (**Home**)
- Dispatch wingman on mission and order him to return to base (**End**) or join up (**Del**)

A squadron leader cannot add new objects to the mission or change properties of the existing ones. His goal is to achieve the mission objectives with least losses. The success of a squadron leader mission is determined only by the actions of the squadron irrespective of how lucky the other allied forces were.

General mission

Combat missions of the General mission class are the most difficult for planning. They require fine tactical thinking. For example, he can be ordered to defend a city from enemy aircraft raids, or to deliver a mass airstrike on enemy installations.

To achieve the mission objectives as a general, you have at your disposal considerable resources including a range of aircraft, SAM systems, radars, all types of aircraft ordnance, and unlimited fuel supplies. Note that in any general mission you can remain as an observer or take part in the mission as a pilot or squadron leader. In distinction to pilot and squadron leader missions, the program evaluates the success of a general mission primarily by the actions of all the allied air, naval, and ground forces. To a lesser extent the mission result will depend on your actions as a pilot, though it may happen that you will be the very person who will predetermine the outcome of the entire mission.

Loading and Saving Missions

To load a combat mission, select **File, Open Mission**. First, select the mission class in the **List files of type** field, for example, "General Mission". This will display a list of all missions of that class which reside in the current directory. Select the desired mission from the list. The **Title** field will change to show the brief message related to the selected mission. In so doing, the text box below shows the mission briefing.

After you have found the desired mission, load it into the Mission Editor by pressing the **OK** button. If you are already familiar with the mission and don't need to view the map, you can start it immediately by pressing the Run button.

Note that if you try to load a mission while editing another one, the Mission Editor will prompt you to save the active mission.

As soon as you finish planning the mission, you should save it. Otherwise, when you start the mission the simulator will run the old version of the mission. To save the active mission, select **File, Save Mission** or press the **Ctrl+S** keys. The mission will be saved under the same name as when it was loaded into the Mission Editor. Sometimes it may be inconvenient because this erases the initial version of the mission to which you might want to return later. To save the mission under another name, select **File, Save as**. This activates a dialog box where you have to specify a new file name for the active mission. The file extension can be omitted since the Mission Editor automatically adds '.mis' to the file name. To label the mission with a brief message, type the required text in the **Title** field. To complete the saving, press **OK**.

Mission Briefing

When loading an unfamiliar mission, you should first get a description of the mission objectives and operational intelligence. Additionally, this information includes a weather report, and mission start time.

To get a mission briefing, select **Flight, Briefing**. This activates a dialog box like this:

Start time

This field shows the time of day at which the mission starts. The time of day affects the colour palette used by the simulation module. Note that the **Start time** field cannot be edited unless you create a new mission (see Chapter 12, "Building new missions").

Title

This field contains the name and maybe a brief description of the mission. You can edit this title while saving the mission.

Description

This text box contains the detailed information about the mission objectives, enemy forces, available resources, and weather.

No matter who you are - a novice pilot or a general, you will be given the mission objectives. For a pilot such an objective may consist in intercepting enemy aircraft or bombing an enemy ground installation. A squadron leader may get the task to perform a fighter sweep over a specific area. And a general may be ordered to defend some area or to plan a massive attack against enemy defences.

If you are a pilot, all you have at your disposal in the mission is your Flanker. A squadron leader can use a formation of four fighters. A general may have a whole selection of aircraft, ships, SAM system and EWR stations. The program does not impose any limitations on the aircraft weapons and fuel load.

You should take good account of the meteorological conditions. For example, TV-guided missiles and bombs can only be used in fair weather, and cloudiness may degrade guidance of IR missiles. The air temperature and wind influence the thrust and manoeuvrability of your aircraft.

You can print the contents of the briefing on your printer by pressing the **Print** button.

Once you have understood the information in the briefing, turn your attention to the map. The map will show you the targets you must attack or defend. By convention, the targets to be attacked (SAM sites, ships, buildings, ground vehicles, and so on) will be marked by pink flags and those you must defend from enemy attacks by blue flags.

Understanding Combat Tasks

Each active ground, naval, or airborne object taking part in the mission has a specific task that it carries out according to a particular degree of “artificial intelligence”. Besides, there are static ground objects (tanks, automobiles, etc.) which in the current version of the sim cannot move and are not provided with their own logic. However, they serve as potential targets for attacking or defending.

The main distinction of an aircraft from other active objects lies in the fact that you can (and must) plan for it a certain combat task according to which the aircraft will act. (You should create the flightplan, choose the weapons and fuel load, allocate the targets). As for ground and naval objects, you can only specify their locations. Nonetheless, our simulator will allow you to specify the skill level for both the pilots or crews of aircraft and the crews of SAM systems, ships or the personnel of EWR stations. One or another skill level specified for an object will dictate its tactics. Our program allows you to specify for each active object one of the following skill levels: Average, Good, High, Excellent. On the whole, the higher the skill level the less the reaction time of the object and the less the time the object spends on reaching a decision about warding off the threat or attacking the target.

Computer-controlled (automatic) aircraft should know how to accomplish their combat tasks because aircraft of the same type can act differently even within the limits of the same mission. For example, the first MiG-29 may effect an intercept, the second - fly a simple CAP mission, whereas the third MiG-29 may seek and destroy enemy radars. Apart from the fact that the type of combat task determines the tactics of the aircraft, it also affects weapons selection. In particular, this means that if the aircraft gets a CAP task you won't be able to load bombs onto it.

To carry out the combat task allocated to your aircraft, you have to do it yourself. By this is meant that if you have chosen (or you have been allocated) a bomb strike, then you have to fly the aircraft to the bomb delivery point and deliver the bombs on your own, though you can get some help from the autopilot. Furthermore, the type of combat task allocated to you and the real results of its execution are taken into account during evaluation of the success of your mission.

Note that the choice of a combat task only decides the general behaviour of the aircraft and the available options of weapons. During the same mission the aircraft can carry out various combat actions. (Though in practice this situation is relatively infrequent.) For example, at one waypoint a Su-27 can drop bombs onto a target, and at another waypoint it can carry out close air support (CAS) of ground forces using unguided rockets.

The following are descriptions of combat tasks that can be assigned to aircraft. Naturally, you can allocate only certain combat tasks to a specific type of aircraft. It would be strange if you could assign an intercept task to the Su-25 or a bombing task to AWACS aircraft.

Nothing

By default, each new aircraft added to a mission is devoid of any specific task. Correspondingly, it will not have any loaded weapons apart from, may be, the cannon. Such a plane does not take part in any active actions against enemy aircraft or ground installations and just follows its route. Under the threat of an enemy attack the aircraft will try to evade it.

Intercept

This is a defensive tactic whereby the aircraft must carry out an active search of incoming enemy aircraft. This type of combat task is reserved for large scale defence and active patrolling and you should not use it while defending a small area or a local installation. The interceptor while chasing the enemy may deviate far from his planned route and the area he is supposed to defend will be left undefended.

This task supposes the use of both long-range and short-range AAMs (R-27 Alamo, R-73 Archer) for intercepting enemy aircraft and cruise missiles and the use of R-77 Adder missiles for intercepting enemy guided missiles. The most suitable aircraft for intercepts are the Su-27 and the MiG-31. Among western fighters this task would be typically carried out by the McDonnell Douglas F-15, which carries four medium-range AIM-120 AMR AAM missiles and four short-range AIM-9L Sidewinder missiles.

Fighter sweep

The fighter sweep mission is a combat task that involves combing air space to attack enemy fighters or other types of aircraft. The main objective of a fighter sweep is winning air superiority and to ensure unimpeded use of the air space by allied aircraft.

In a fighter sweep you can use the Su-27, MiG-29 MiG-23, F15 and F16 fighters. All the aircraft taking part in this task carry long-range and short-range AAMs and the Su-27 in addition to them may carry an external active ECM station Sorbtsiya.

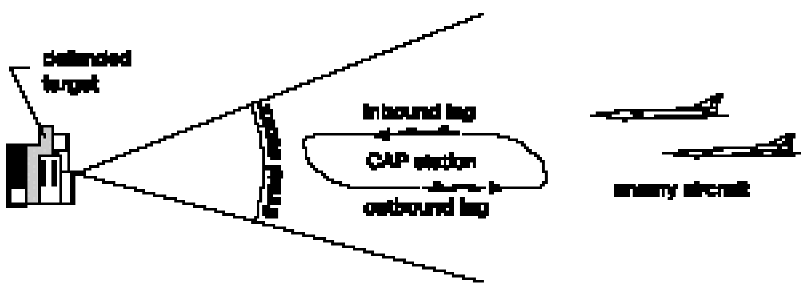
Since the aircraft taking part in a fighter sweep may find themselves at a considerable distance from their airfields and take part in prolonged dogfights, their fuel load will be a crucial factor. Certain aircraft such as the MiG-23 and MiG-27 can carry additional external fuel tanks.

Combat Air Patrol (CAP)

For the purposes of defending a relatively small area you can use the Combat Air Patrol (CAP) or Ground Alert Intercept (GAI). In a specific situation the choice of a CAP or GAI mission depends on many factors. Among them are the nature of a probable enemy attack, reliability of the information about its route, the number of defending fighters and their capabilities.

The CAP mission implies flying a large rectangular pattern round and round following a given route to defend some area from enemy aircraft. This type of task does not involve spotting and destroying enemy ground targets or a significant deviation from the planned route to intercept aircraft. One of the advantages of the CAP is the possibility of intercepting enemy aircraft at long distances from the target being defended. This is especially important if you expect enemy aircraft armed with long-range stand-off weapons (for example, cruise missiles) that can be launched many miles away from their targets. Besides the time factor, the CAP is well suited to situations where the direction of approach or route of enemy aircraft is known with some degree of certainty.

A typical CAP route degenerates into a heavily flattened ellipse, the long axis of which is lined up in the direction of possible threat (see the figure below). You can set up a CAP station for patrolling with the use of both one and several aircraft. (For example, it can involve two aircraft flying toward one another.)



The distance at which you place a CAP station depends on many factors: the number of patrolling aircraft, the size of the area being defended, and the nature of its ground based air defence. Sometimes the use of GAI or only ground based air defence may be more efficient. But beware of standoff weapons!

When planning a CAP mission, the choice of altitude and speed of flight is of no small importance. Plan to patrol at the expected altitude of the incoming enemy aircraft and take your weapons load and weather into account. Be aware that high altitude CAP will make life for low level interdiction real easy and a high/low CAP sandwich might be more suitable.

The crucial factor while patrolling will be the fuel load limiting the distance and duration of CAP.

All automatic aircraft in our simulation stop patrolling and return to base in a straight route as soon as their fuel falls to the guaranteed minimum required for the return flight.

On the whole, the use of CAP alone for air defence is difficult and insufficient. However, sometimes CAP may be fairly well suited, especially in the following circumstances: the area being defended is not very large; your fighters have sufficient resources; the sector of possible threat is limited; and if the enemy attacks in small force without large fighter escort.

Ground Alert Intercept

In many circumstances GAI usually proves to be preferable and more flexible for the organisation of air defence than CAP. When taking part in a GAI mission, the aircraft is on alert duty on the runway with warmed-up engines. On receiving AWACS targeting data the aircraft takes off and effects an assisted intercept. Since high top speed and climb rate are extremely important for GAI, the most optimal aircraft for this task are the Su-27, MiG-29 and MiG-31. Note, however, that in our program the GAI task can be allocated only to automatic aircraft. We wouldn't want you to stay Earth bound sitting on hot alert in the cockpit for long stretches of time waiting for intercept data. This can prove to be very boring and frustrating. If the enemy attacks with several aircraft, the aircraft on GAI duty will take-off one after another intercepting one enemy aircraft each. (Provided that you have allocated the GAI task to a sufficient number of aircraft.)

When planning this type of mission you don't need to design waypoints and action points. All you have to do is just set the takeoff point, declare it as a GAI station, and let the EWR and AWACS systems vector the aircraft accordingly. Note that intercept aircraft rarely have a complete weapons suite in order to offer maximum rate of climb and manoeuvrability. Note that when planning GAI the aircraft on hot alert don't appear on the runway until the target data becomes available.

The GAI concept is not without drawbacks. First of all, the EWR systems must detect enemy aircraft in good time; otherwise the aircraft on GAI duty on the airfield may become sitting ducks. Furthermore, to repulse attacks from any direction, the airfield with the aircraft on GAI duty must be sufficiently close to the installations being defended.

Escort

This task is allocated to fighters and involves escorting allied aircraft (transport aircraft, bombers, or attack aircraft) and defending them in some air corridor along the route from possible attacks of enemy aircraft. In doing so the escorting fighters should not engage in fights with the enemy aircraft if the latter do not close in on them and do not display aggressiveness.

When planning an escort task, it is essential that the speeds of the fighters and the aircraft being escorted are close to each other. To simplify an escort intercept make sure that the times on the escort intercept waypoint are identical as should be altitude and speed for the fighters escorting and the escorted aircraft.. You should plan the number of escorting fighters depending on the importance of the combat task allocated to the escort and the probability of an encounter with enemy interceptors on route.

Antiradar

This task involves searching for enemy EWR stations and SAM sites in a given area, and attacking and destroying them using antiradar missiles of the Kh-25MP Karen or Kh31P Kegler types. Note that you cannot use antiradar ASMs against airborne targets (for example, AWACS aircraft), as antiradar missiles are not designed to track fast moving manoeuvring targets.

Antiship strike

This task consists of actively searching for enemy surface ships in a given area then attacking and destroying them. In so doing you can use antiship missiles of the Kh-15 Kickback, Kh-31A Kegler, Kh-35 Krypton types or cruise missiles of the Kh-55 Kent and Kh-65 types.

Pinpoint strike

The Pinpoint strike mission involves active search for ground and surface targets in a given area and attacking and destroying them using precision missiles of the Kh-25 Karen, Kh-29 Kedge types, or cruise missiles of the Kh-55 Kent and Kh-59 Kingbolt types. Besides the above weapons, to deliver a pinpoint strike, the aircraft can carry guided bombs of the KAB-500 or KAB-1500 types.

Ground attack

This task consists in purposely searching for enemy ground targets (plants, railroad stations, airfields) in a given area then attacking and destroying them in general using bombs. This type of mission usually involves using unguided bombs weighing from 250 to 1500 kg or the KMGU unified containers. In addition, the aircraft can destroy targets with the aid of unguided rockets.

Runway Attack

This task is assigned to the aircraft which are planned to deliver concrete-piercing bombs and KMGU-2 bomblets onto runways.

Close Air Support

CAS involves actively searching for enemy ground targets on the battlefield and destroying them. Here absolute precision in delivering strikes is not of crucial importance. This type of mission usually involves using the S-8, S-13, S-24, and S-25 unguided rockets and unguided bombs. The Su-25 ground attack aircraft is best suited to CAS, though such planes as the Su-27, MiG-29 or and MiG-27 can successfully handle this task.

AWACS (Airborne Warning And Control System)

This task can only be allocated to the A-50 AWACS aircraft, which is a highly modified version of the IL-76 transport aircraft. The AWACS aircraft flies according to a planned straight or circular route and alerts allied aircraft, SAM sites, and ships when it detects enemy aircraft.

The advantages provided by the AWACS aircraft are evident. Furthermore, the S-300PMU and Buk SAM systems can receive targeting data directly from the AWACS even when their own acquisition radars have been destroyed. The sole drawback of the AWACS aircraft is its high vulnerability, especially as it is a much prized target for enemy fighters. Often you can use ground EWR stations instead of the AWACS aircraft or to assist them.

Placing Aircraft

After you have read the mission briefing and have understood the mission objectives you can get down to the business of realising it. The most logical first step is allocating combat tasks to aircraft. In the Pilot mission class, your Flanker already has the combat task and you can start the mission straight away. In the Squadron Leader mission class you should create a route for your Flanker, choose pilots for your mission and select the corresponding weapons and fuel loads for the aircraft. With a General mission, you should first of all select aircraft suited to the combat task. If necessary refer to the Electronic Encyclopedia (click the Encyclopedia button on the Standard toolbar). The Encyclopedia contains all the placable objects used in the program, active or passive, accompanied where necessary by brief descriptions of their main specifications.

After you have decided which aircraft you will use in the mission, you should carefully create flightplans for them. We recommend that you plan a combat task for an aircraft in the following steps:

1. Select an aircraft and sortie. Specify a skill level for each aircraft in the formation
2. Pick weapons and fuel loads
3. Place waypoints, i.e., roughly design a flight plan from take-off to landing.
4. Set waypoint objectives. You should assign particular actions to be executed by the aircraft at specific waypoints. We call these waypoints action points.
5. Re-analyse route and place waypoints with more precision. Have a good look at times!
6. Double check the whole route and all attributes.

Selecting aircraft

To set up a new aircraft, open the Aircraft dialog box by clicking the Aircraft icon on the Planning Toolbar. This dialog box is initially shaded until you place the first waypoint for a new aircraft.

1. When building a new mission, you will be able to change the side on which the aircraft fights using the **Side** field. Otherwise, this field shows the name of the country owning your aircraft according to the conditions of the given mission.
2. As a general, you have at your disposal any type of aircraft. Select from the list an aircraft for which you want to plan a combat task. If you are a Squadron Leader you can only select Su-27s.
3. Select a type of combat task in the **Sortie** field. Note that a list of possible combat tasks depends on the type of aircraft. For example, the A-50 aircraft is only allowed to fly AWACS missions, whereas the Su-27 has the longest list of available combat tasks. The chosen combat task determines the logic of behaviour of the aircraft in the mission and the standard weapon loads available.
4. Assign take-off time for the aircraft/formation relative to the start time of the entire mission. For GAI aircraft this will mean the start time of duty.

5. Select the number of aircraft in the wing (including your Flanker if you are going to fly in this formation). A formation can consist of up to four aircraft. Do not try to always select the maximum number of aircraft since when the program evaluates the success of the mission it not only accounts for destroyed targets but also for the expended resources and lost aircraft.
6. Assign a skill level to a pilot/crew for each aircraft in the formation. You have the choice of four skill levels: Average, Good, High, Excellent. Assigning one or another skill level decides the tactics of the aircraft: the higher the skill level the less the response time of the pilot/crew and the less the time spent on working out a decision when a threat or conditions for using weapons arise.
7. You can add a random factor to the mission, to make it more interesting and unpredictable. If you check Random Factor in this dialog box then the actual sortie start time for the given wing will differ from that specified in the Start at field by up to 15 minutes and there is even a small probability that the aircraft won't take off at all.

If you want to fly in a formation of the Su-27 aircraft yourself, select "Me" in the Leader field. Note that there can be only one "Me" per mission.

Selecting weapons and fuel load

To move to the dialog window controlling the loading of weapons and fuel, click the Payload button in the Aircraft dialog box. The Payload dialog box will appear.

In the **Weapons** field you should choose weapons best suited to the combat task assigned to the aircraft. All available weapon load options are pre-set. That is, you cannot select missiles and bombs at will. This is due to the aircraft's design limitations in strength, circuitry and mod state. However, owing to the large number of standard weapons loads you will surely be able to find the one best suited to the assigned task. Furthermore, this removes the problem of finding the right distribution of weapons on the pylons and saves you from the risk of overloading the aircraft.

All the aircraft in a formation will get the same weapons load. When you select a weapon load option, a detailed list of the weapons included in the option appears to the right of it. If you wish, you can click the **Preview** button in the Aircraft dialog box to have a look at a model of the aircraft with the attached weapons.

After you have loaded the weapons, choose a fuel load for the aircraft in the **Fuel** field. Base your choice on approximate length of the planned route, the type of mission and the type of weapons loaded. Remember that the heavier the weapons load the more thrust the aircraft should deliver and so the more fuel it should expend. However, an excessive fuel margin makes the aircraft heavier degrading its manoeuvrability characteristics and making it an easier target. Therefore, choosing the optimal fuel load and weapons load is not an easy task.

A fuel load is chosen from a list and it is shown in percent of the maximum capacity of the internal fuel tanks. Allowable loads lie in the range from 30% to 100%. Some standard fuel loads also provide jettisonable external fuel tanks. In particular, they are provided for the MiG-23, MiG-27 aircraft (one tank attached to the central pylon) and the Su-25 and MiG-29 (two tanks attached symmetrically to the right and to the left of the centre). Your Su-27 always has the possibility of jettisoning surplus fuel (the **L** key) and weapons (the **Ctrl+W** keys) in flight, should the need arise to lighten the aircraft. (If you need high manoeuvrability or you are trying to fly a damaged aircraft back to base).

The weight of selected weapons, total fuel weight, weight of unloaded aircraft, and maximum take-off weight are shown on the lower left.

Designing routes

After you have set up the characteristics of an aircraft/formation you can get down to designing a route. A route consists of a series of waypoints, each being characterised by altitude and airspeed. In addition, a waypoint is always associated with a particular action, for example, a take-off, landing, a turn (*a turning point*), an attack on a ground target using unguided rockets, delivery of bombs, and so on. The map shows turning points as circles with numbers (a selected route) or without such (an unselected route), and action points as triangles, also with or without numbers.

Setting an initial waypoint

Your first task while planning a route consists in placing its characteristic waypoints starting in principle with the take-off point and finishing with the landing point. Focus your attention on the general direction and shape of the route. You will be able to place waypoints with more accuracy later.

Place the initial point of the route by clicking at the required location on the map. This activates the Waypoint dialog box (see the figure below). Note that this dialog box can be invoked at any time by clicking the **Waypoint** button in the Aircraft dialog box.

If you name the first waypoint of a route “Takeoff” and place it near a particular airfield, it will be automatically dragged to this airfield. The aircraft’s altitude and speed in the takeoff waypoint will be set to zero. The take-off waypoint gets ordinal number 0 and is drawn with a special symbol on the map.

However, the first waypoint of a route can be a fictitious point in the sky rather than the take-off point. In this case, the aircraft enters the game straight from this point, bypassing the takeoff. Therefore, you should set for this point a particular altitude and airspeed. Of course, in real life aircraft can't just appear from thin air, but here it is justified as sudden appearance of an aircraft can have the explanation that target detection equipment was not capable of seeing the aircraft or the said aircraft joined the theatre from outside the Crimea (typical for long range aircraft such as Su-27, Tu-22, IL-76, A-50, etc.).

Placing waypoints

After you have set up the first waypoint of a route, place the remaining waypoints by sequentially clicking the left mouse button in desired locations on the map. All the waypoints will be displayed in the colour of the selected country. By default, all waypoints are turning points. The maximum allowable number of waypoints in a route including the take-off and landing points is 16 (numbered from 0 to 15.)

For the last waypoint of the route specify "Landing" in the **Action** field. This automatically zeroes the altitude and speed and drags the point to the nearest airfield. A landing point is also shown on the map with a special character.

As with the initial waypoint, you can avoid a landing and just let the aircraft vanish into thin air. This would represent the typical case of AWACS aircraft which rarely even get close to the theatre of operations. To do so, it is sufficient to leave the last waypoint as a turning point.

To finish planning a route, click the right mouse button. After that you can start designing a route for the next aircraft or formation of aircraft. To complete placing new aircraft close the Aircraft dialog box, deselect the Aircraft button on the Planning toolbar or click the right button twice.

Moving waypoints

To edit an existing route, you should first exit the Aircraft set-up mode. Then choose a route for editing by clicking any of its waypoints. The selected route is shown by circles and triangles with ordinal numbers of waypoints inscribed in them. The current waypoint and the connecting lines light up in yellow.

If the Aircraft and Waypoint dialog boxes are closed, you can restore them on screen by clicking twice on any waypoint or by pressing Alt+Enter with a waypoint selected or finally via the object's shortcut menu. (To open only the Waypoint dialog box click on the desired waypoint once).

Select a desired waypoint and drag it to a desired place on the map. If necessary, apply zooming so that you can place waypoints more precisely. For precise placing, you can refer to the geographic coordinates shown on the Status Bar. The coordinate grid (toggled by Ctrl+G) will also help you in placing waypoints.

The special buttons in the Waypoints dialog box described in the table below can be of help to you while you are working with waypoints:

Button	Action
Ins	Inserts an intermediate waypoint between the current and the next waypoints. The new point is automatically inserted halfway between the existing ones, and all subsequent waypoints will be renumbered. You can move the added point to any place in the usual manner.
Del	Deletes the current waypoint (also the Del key)
Next	Goes to the next waypoint
Prev	Goes to the previous waypoint

Setting waypoint altitude and airspeed

While editing a route you can change the altitude and airspeed values at any waypoint. The Mission Editor will automatically monitor the changes and refuse any impossibilities. For example, if you try to lower a waypoint below an allowable threshold (30 or 100 metres depending on the type of aircraft) or raise it above the permissible operational ceiling for a given aircraft, the Editor will set the altitude respectively to the minimum or maximum allowable values for the selected type of aircraft. The same is true of limitations on airspeeds.

More complicated errors are those relating to the laws of physics of movement. For example, you could inadvertently place waypoints very close together with vast differences in altitude or speed. Naturally, the aircraft may simply not have the capacity or time to do what you expect. Similarly, if the next waypoint is close to the current waypoint and is placed at a significant angle to the direction of flight the aircraft may not have the turning capabilities to fly through the next waypoint. In this case, it will follow the remaining part of the route unless the skipped waypoint is an action point to which you assigned a particular task such as bombing.

When planning routes you should take into account that different types of aircraft can have significantly differing rates of turn and radiuses of turning circle (from several hundreds metres to several kilometres).

When building a low level mission, don’t worry about planning for high ground as the aircraft will automatically climb to a safe clearance altitude as if “terrain following”. This feature will significantly simplify your low level routing.

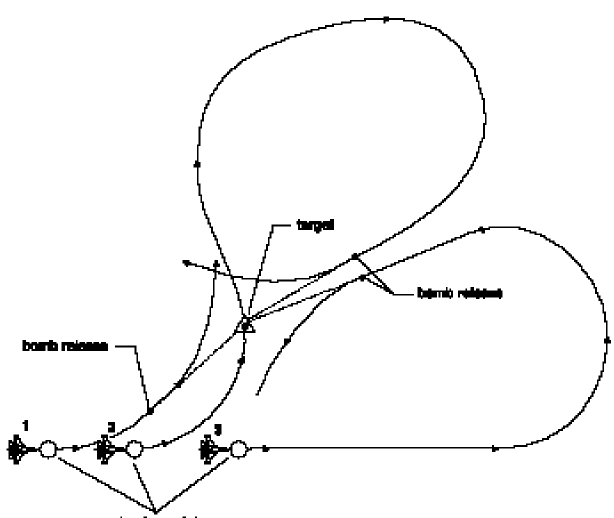
The time of arrival to a particular waypoint is calculated automatically based on the altitude, speed and route length. You can use it to coordinate actions of different aircraft such as escort intercept and the like by changing speed, altitude, waypoint placement and seeing what happens to the estimated time over (ETO) the given waypoint (the **ETO** field of the Waypoint dialog box). However, this time is estimated approximately so don’t rely only on it. Furthermore, an action point involving strike point by delivery of high speed stand-off weapons (such as Kh-15 or Kh-31A air-to-surface missiles) will see earlier ETO of the weapon than that estimated for the aircraft. Note also that if the target is hit by a stand-off weapon the delivering aircraft will not fly to that waypoint but to its next action point or base.

Waypoint action assignment

When you have placed all the base waypoints of a route, you can turn to the task of specifying action points. The table below contains brief descriptions of all the types of action points available to this sim.

Action	Meaning
Take-off	Take-off point associated with a particular airfield
Landing	Landing point associated with a particular airfield
Begin loop	Begin flying a "closed-loop" route (for CAP and AWACS tasks). Used in conjunction with the End Loop point
End loop	Marks from where the aircraft returns to the Begin Loop waypoint. The aircraft will be flying the loop until the amount of fuel in its tanks reduces to the guaranteed minimum for the return flight. When this occurs, the aircraft will automatically fly to the planned landing waypoint, following the shortest track
Escort Intercept	Waypoint of the escorted aircraft where the escorting fighters are to join
Wingmen ON	Gather wingmen into tight formation
Wingmen OFF	Loosen up the formation
Bombing	Deliver bombs to the target specified by the given action point
Missile2Ground	Fire an ASM at the ground target specified by the given action point
Missile2Ship	Fire a missile at the ship specified by the given action point
Rocket attack	Fire unguided rockets at the target specified by the given action point
Lock altitude	Disable terrain following mode and force the aircraft to fly at the given altitude. Care should be taken when planning low-level routes with altitude locked to prevent the aircraft from crashing into mountains
Unlock altitude	Return to terrain following mode

Note that when an action point corresponds to a target, the real moment for releasing bombs or launching missiles comes significantly earlier. However, situations may arise where the aircraft does not have time to line up on the target correctly. The figure below shows three different



situations for an aircraft dropping unguided bombs on the specified target. Aircraft 1 flies a correct route where it has enough distance to line up on the target. Aircraft 2 will close in on the target at too great an angle, to deliver the bombs accurately. Aircraft 3 would not be able to fly through the planned action point at all. In the second and third cases the aircraft will fly away from their respective targets, make turns and deliver the bombs on the second try. Only after that will they resume flying their planned routes.

To estimate approximate length of the current route and flight time, you can click the **Summary** button in the Aircraft dialog box. You will be given general information about the route length, average speed, flight time, take-off time. Note that estimated time over the current waypoint (ETO) can be viewed in the waypoint dialog box; this will help you plan coordinated attacks.

The real data might differ from the planned data since it is difficult to calculate the exact time spent on the take-off and landing and the total distance the aircraft flies on route taking into account all turns and altitude changes. Therefore, the data shown in the dialog box should be treated as an estimate. Time spent on the take-off and landing is considered to be standard and varies from 7 to 12 minutes depending on the aircraft type.

Placing Radars, SAMs and Ships

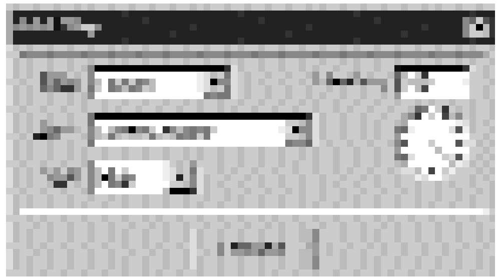
If you are planning a General mission, you will probably have EWR stations, SAM systems and ships at your disposal. To make the best use of them, you should evaluate expected enemy forces, the direction of their possible approach, and competently use terrain. In addition, you should be well acquainted with specifications of weapons and radars. Chapter 8, "Understanding SAMs and Countermeasures", and the 3D Encyclopedia will help you in this respect.

When you are placing the given types of active objects, you should specify the country to which they belong (only when building new missions), their location and orientation, that is, an angle between the object’s longitudinal axis (stern-bow) and due North. For most radars, SAMs, and ships orientation is of no concern, since the radars have a circular scan and launchers are oriented upright or can turn in any direction. However as a purist you might want to position the launcher on a road or in a parking slot where orientation is nice.

You should assign a skill level to the crew or personnel of each EWR station, SAM system and ship. You have the choice of four basic skill levels: Average, Good, High, Excellent. The higher the skill level the less the object’s response time and the less the time spent on decision making when a target appears. If you want that the skill level of a particular system would be assigned randomly at run time, you should specify the “Random” skill level. Note also that if the skill level is set to “Random” there is a chance that the system may not appear in the mission at all.

To set up a new SAM system, EWR station or ship, do the following:

1. Click the required icon on the Planning Toolbar. This activates the corresponding dialog box, for example:



   Note that when starting to place new objects, the dialog box is shaded until you place the first object.

2. Click on the map where you want to place the object. The default symbol for the object will appear and the dialog box will allow input.

3. Choose a country (allowed only for new missions), the type of system, and a skill level for its crew. If you want to look at a 3D model of the object and its specifications, press the **Preview** button in the dialog box or click the Encyclopedia button on the Standard toolbar.

4. To set an orientation of the object you can enter the exact angle in the **Heading** field or use the special circular scale in the form of a clock. 12 o'clock corresponds to due North, 3 o'clock - due East, and so on. To set the orientation, just click in the required place on the clock-face or rotate the arrow by dragging it with the mouse.

5. Repeat steps 2-4 until you set up all the objects of the given class.

All units comprising a SAM system are placed individually. Note that you cannot place launchers further than 1000 meters from their radars. For a particular SAM system, when a surveillance radar (or engagement radar if this is the only radar unit) is placed on the map, it will be surrounded by a circle indicating the area where you should put the remaining units of the given system. If the units are not placed properly, the SAM system will fail to work.

After you have placed all the objects, you can exit from the set up mode by clicking the corresponding sunken button on the Planning Toolbar . Now you can select and move placed objects and change their properties using usual methods.

Note. When building new missions you have the possibility of setting up static ground and naval objects such as tanks, armoured vehicles, submarines and many others. Such objects can serve as targets for attacking or defending. You set them up similarly to radars or ships with the only difference that you cannot specify a skill level for static objects. To place static objects, use the Static Object button on the Planning Toolbar and proceed as described above.

Debriefing

After you have placed all the objects, save the mission and start it. Now the success of the mission is in your hands, or at least a part of it is.

A mission is ended in the following events:

1. You have quit by pressing **Ctrl+Q;**
2. Your aircraft has crashed and you have refused to continue the mission without your participation;
3. Your aircraft has successfully flown the mission and has landed. You refused to continue the mission without your participation

You will obviously be interested in the results of the mission. To get the statistics on the sequence of events, select **Flight, Debriefing**.

This activates a dialog box in which you will see a chronologically ordered list of all major events that have taken place in the last mission. Among those events are:

- Appearance of a new aircraft in the mission
- Launch of an unguided rocket, AAM or SAM
- Bomb release
- Gun/cannon fire

For all the events the list shows the side and the name of its initiator, the name of weapons employed and the outcome of such a deployment on the target. If the target has been destroyed then there will an indication of its category (primary, secondary, or random).

Using this list you can analyse the sequence of events related to your Flanker, to your wing or to all weapons of your side. Since the list can by quite long, you can filter information selecting only information of interest to you. For example, you can specify that only events related to your wing should be displayed (to do this, use the **Initiator** combo box and specify “My wing”). If you want, say, to explore only missile and shell hits then select “Hits” in the **Target Status** field, and so on.

At the bottom of the dialog box you will find the overall mission statistics concerning successful kills/destroyed objects and your losses.

If necessary, you can print the current information by clicking the **Print** button. To save the statistics to disk, press the **Save** button, then enter a name of the file in which you want to store the statistics. (By default, its name coincides with the name of the mission file and has the ‘.stt’ file extension). You will be able to view the saved statistics at any time later by selecting “Statistics” as a file type when opening missions.

Note. Besides the ability to analyse results and sequence of events, the program also allows you to record, edit, and play the video sequence for any mission. For more info on video edit, turn to Chapter 13, "Miscellaneous".

Chapter 12. Building New Missions

The option of creating new missions is among one of the more important features of the Mission Editor. With its help you can simulate practically any combat situation and perform the mission yourself or distribute it to your friends or the world at large via the Internet. If you intend to give your mission to other players, you can limit their available resources and hide information on enemy objects

In this chapter we shall teach you how to create new missions. You are supposed to have mastered the previous chapters on the Mission Editor since they describe the basic principles of work and methods of mission planning.

While designing new missions we recommend that you follow the sequence of steps presented below.

Prepare for a new mission

You can create new missions from scratch or based on existing missions. To build a completely new mission, select **File, New Mission**. This will display a clear map with symbols of airfields.

To create a new mission based on an existing one, you should load the latter in the usual way, plan the new mission and save it under another name. Note, however, that as the basis you can use only those missions which are fully accessible for editing. For example, you will not be able to create a new mission based on a Pilot mission since the latter always contains inaccessible information about enemy objects. Besides, in combat missions your resources are limited.

To get access to all mission resources, you should know the password under which it was classified. To do this, select **Edit Mission** from the **Edit** menu and enter the correct password. In case of success you will get full editing access to the mission. In so doing, the objects hidden from players will remain invisible on the map. However you'll be able to display them using the Object Status dialog box, which will be described later.

Think up a strategic situation

You have to decide which sides will take part in the mission and how the situation will take place. If you plan to create a complex mission with a lot of active objects, we suggest that you first plan the situation on paper, conceptually at least.

Specify the minimum and maximum skill levels which will be applied to all objects taking part in the mission. (See Chapter 10, "Getting Started"). To do this, select **Options, Skills and Survivability**. The higher the minimum level, the higher the skill levels of all the active objects in the mission.

Specify a tactical situation

Make a decision into which class the new mission should fall. Such a choice determines which objects in the mission you will place yourself and which ones a player should place on his own.

Now you should decide specific tasks and resources for their accomplishment. As an example:

"Two Tu-22 strategic bombers escorted by a formation of four Su-27 fighters will deliver a bombing strike on the Sevastopol bay. A formation of four MiG-29's will carry out a fighter sweep in that direction preparatory to the strike. To support the strike from the sea, we will send a Moscow class cruiser and a couple of torpedo boats to the bay. To defend friendly airfields, we will place air defence units on the anticipated routes of enemy aircraft. In so doing, one S-300PMU system will perform early detection and destruction of enemy aircraft and two Tor systems will defend the close approaches to the airfields. To provide early warning for our aircraft and air defence systems we will use one ground-based EWR station and one AWACS aircraft".

Do not try to use too many active objects in one mission because this may significantly increase the volume of computations, reduce the speed of action to a certain degree and make life hugely confusing.

Place active objects

After you have assigned the tasks in broad outline, get down to detailed planning of the mission. Plan routes for all of the aircraft, place ships, radars, and SAM systems. In so doing, you may find useful the following recommendations:

- Airfields that belong to one side should be at sufficiently long distances from the enemy airfields and their air defence.
- Do not place the landing waypoints of allied aircraft on an enemy airfield. Neutral aircraft can take off and land on any airfield.
- Plan aircraft routes taking enemy air defence into account. This is especially important when planning routes for AWACS aircraft.
- Do not allocate too many targets to one aircraft or wing (1-2 primary targets is the norm). Do not also assign several tasks to one aircraft.
- If you want aircraft of the warring sides to encounter each other in the air, plan their routes with regard to the abilities of aircraft to detect the enemy (the route geometry, the direction and range of detection). A practical range at which an aircraft will engage in combat with the enemy depends on the types of both aircraft and on the assigned task. For example, for escorting aircraft such a range is about 20-30 km, and for interceptors - 50-150 km.
- The resources of both sides should be balanced.
- Do not concentrate too many active objects in one place.

Place static objects

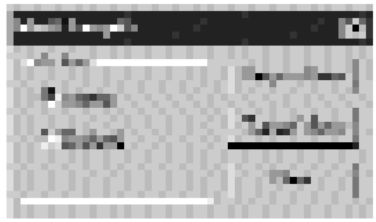
If necessary, you can place various ground-based and naval static objects (tanks, automobiles, submarines and so on), which themselves do not take part in the mission but can be used as targets for attacking or defending.

Note that static objects like active ones are saved in the mission rather than in the map. This means that in the next new mission you will not find those extra static objects placed in some other mission. However, to use the static objects from another mission, create a new mission using the existing mission as a basis.

Mark targets

To ensure that the player understands which targets he or she should attack or defend first, mark the objects representing the mission primary targets by special flags. The program accounts for these marked targets when estimating the success of the mission in the debriefing.

To mark targets, click the Targets button on the Planning Toolbar. This invokes the following dialog box:



Mark the object by clicking it with the left mouse button. Indicate in the dialog box what kind of targets you want to set: attack or defend. Targets to be attacked are marked with pink flags, and those to be defended are marked with blue flags. To unmark an object click it with the left mouse button and press the **Clear** button.

To view the target and the surrounding terrain from a birds eye view at two pre-set altitudes press the **Region View** or **Target View** button. You can print these views in a standard way and use them during the mission as satellite shots.

Note. You cannot mark the terrain elements, small objects like trees and empty locations on the map. Furthermore, we do not recommend you to mark too small objects as the mission objective may become close to impossible.

Specify mission conditions

To introduce some variety in your missions, you can set specific meteorological conditions (select **Options, Met Report**). Weather will affect flight and combat actions of the player's aircraft to a great extent.

You can also specify a survivability level for the player's aircraft. However, we do not recommend you to specify too a low level because this may prove to be extremely frustrating for all but the most experienced.

Make up the mission briefing

To enter a description of the mission, select **Flight, Briefing** (see Chapter 11, "Planning your mission").

Modify object status

Before distributing the mission to other players, you should consider hiding certain objects on the map. Note that you might have hidden some objects as described in Chapter 10 already.
The element of surprise due to insufficient intelligence is fundamental while designing the enemies movements.

Press the Object List button on the Standard toolbar. The dialog box displays a list of selected object types. You can change the Hide and Random attributes of any chosen object type, for example, Type: ZSU-24, Country: Russia, #: 3, Hide: 'H', Random: 'R'.

The objects that display 'R' in the **Random** field will operate in the mission within a certain random factor. For aircraft, enabling this factor results in a certain delay in takeoff time and unpredictability of skill level. For ships, SAM sites and EWR stations the skill level of the crew will also be set in a random way and there is even a small chance that the system may not appear in the mission at all.

To change a particular attribute for specific objects, select them in the list with the mouse and press the corresponding button (**Hide** or **Random**). To select multiple objects, hold down rhe **Shift** or **Ctrl** key while clicking on the objects in the list.

Note. Once you have chosen how you want your objects status to look you must classify the mission to remove the possibility for anybody else to tamper with these statuses.

Classifying the mission and allocating resources

When you have prepared all necessary objects, assign the mission to the desired class and limit the resources. To do this, select **Edit, Classify Mission**. This will invoke the following dialog box:

Select the class you want to assign the mission to. Specify a password, which will be associated to the mission unless changed by you later.

To limit the player's resources in the mission, specify which objects will be at his/her disposal (the **Object class** and **Object type** fields) and how many objects of a particular type (the **#** field). For example, you could give the player only 4 Su-27s for the above fighter sweep mission. Click **Apply** after each allocation of # to each object type. The number will appear beside the type in the list.

N.B. If a mission does not have a password, it will be fully accessible to any player for editing.

Once you have protected the mission, it becomes a fully-fledged combat mission. That is, you will not be able to view or change any information in the mission. To resume editing the mission, declassify it by selecting **Edit, Declassify Mission**, enter the correct password into the dialog box and "shezam" you're back into the Classification dialog box.

Save the mission

To save your mission to a file, select the **Save As** and specify the file name for the mission.

Chapter 13. Miscellaneous

Video Sequences

Our simulation allows you to record and automatically reproduce any mission flown. By editing the recorded sequence and properly manipulating views you can create highly impressive video sequences and show them to your friends and colleagues or to the world via the Internet.

In fact, a demo mission and a video sequence are one and the same and have the same file extension '.trk'. This means that at any time you can stop the playback, take over control of the Flanker and resume flying on your own. The trick is that any video sequence is a timed series of events related to your keyboard and joystick rather than a batch of screen images. Each time you playback a video sequence, the program performs the real mission and automatically reproduces your keystrokes and joystick movements.

Below is a typical procedure for creating video sequences.

1. Load the desired mission.

2. Select **Flight, Record** from the menu. You'll be asked to specify the file name in which you want to store the video sequence. By default, the file name coincides with that of the mission, while the file extension is '.trk'. Press the **OK** button to start the mission with recording to the specified files.

3. Perform the mission as ordinary. Try to concentrate on your flight rather than on outside views - you will be able to select them later. Complete the mission as best you can.

4. Select **Video Edit** from the **Flight** menu to edit the recorded video sequence. As the program plays the video sequence you are allowed to switch to any view. To select the view that suits you the best, pause the program (press S), switch to the desired view, cycle to the object of interest and find the best view point. Then resume the sequence from the new view point by pressing the **S** key again.

   If you don't like the way your aircraft is flying or fighting in the video sequence, press the **Esc** key. The program will display a dialog box with a list of choices. Select **Continue**, if you want to resume the video sequence, **Take Control** to fly and fight on from this moment (the recording will resume), or **Quit** to terminate the video sequence.

   Note that you can run the video sequence through the Video Edit utility as many times as needed until you get the ideal footage.

To enjoy the video sequence you've just recorded and edited, select **Flight, Play**. You will also be able to run it later from within the Open dialog box.

Head-to-Head Missions

This version of the program makes it possible for two players on different computers to fight against each other on the network using the IPX protocol. These are called *head-to-head* (H2H) missions.

A H2H mission initially puts the two Flankers in the air at a certain distance from each other. The aim of both the pilots is to attain a good firing position and kill the opponent using the cannon. The initial mutual location of the two aircraft is generated randomly; however, in every case they will always be the in equal tactical situations. For example, the aircraft can be on head-on courses, opposite courses, or on the same courses. Head-to-head missions may also differ depending on the weapons load. Normally, both the aircraft carry no weapons except the GSh-301 cannon.

Unlike the other types of missions, head-to-head missions give you virtually unlimited cannon ammo. Initially, the shell counter on the HUD is set to 150. Each time you run out of ammo, the counter will be reset to 150 again in 3 minutes. In contrast to the cannon ammo, the fuel load is limited and consumed as ordinary. However, if low on fuel, you can land and refuel your jet, then take-off to resume the dogfight. To refuel the Flanker on the airfield, hold down the L key to fill your fuel tanks up as required. Check the amount of fuel on the Fuel Gauge. Note that in flight the L key is used for fuel dumping.

Note. Currently, there are no active objects in head-to-head missions. This feature will be implemented in the following releases of the program together with the multi-player option.

To start a H2H dogfight, do the following:

1. Make sure both your computers are connected through the network running the IPX protocol.
2. Each of the players should load the same head-to-head mission (select “Head-to-head mission” as the file type) into the Mission Editor and select **Flight, Start**. Both the aircraft will be put on hold in the air and the countdown will start on the screen. As soon as it zeroes, the aircraft will be automatically released, so be ready to take over control and fight.
3. The mission will end when both players quit by pressing **Ctrl+Q**. Then you can go to debriefing and see a detailed list of events.

Note that in H2H missions you can’t suspend or accelerate the program.

Preferences

Preferences make it possible to customise the program to suit you best. Some of them affect the simulation module, the other, the Mission Editor.

To specify your preferences, select **File, Preferences**. From the multi-page dialog box select the desired page by clicking its heading.

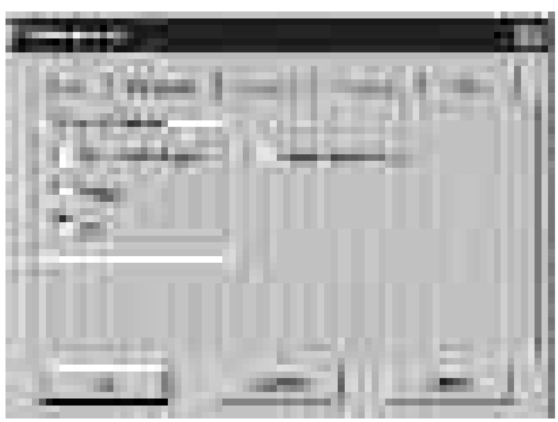
Measurement units

If the standard measurement units used in the Mission Editor are inconvenient to you, choose those that suit you best. For example, you can specify airspeed in m/sec, km/h, knots. Furthermore, you can specify it as indicated or true airspeed.

Note that these settings are applied only in the Mission Editor; the simulation module uses standard Russian measurements: km/h for airspeed, metres for altitude and distance, and kilograms for weight.

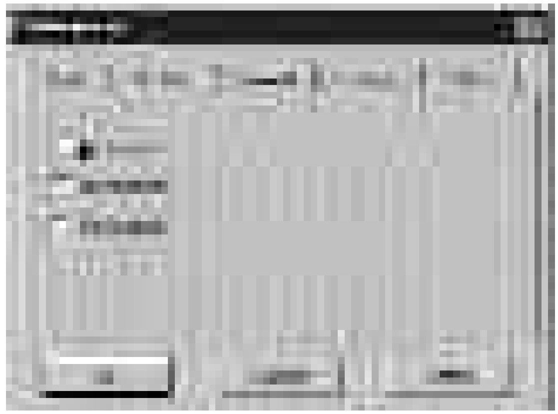
Details

Here you can specify how the program should display the sky and the terrain, and what built-in ground objects (trees, roads, buildings) can be shown on the map when flying missions. The less details on the screen the faster the program runs so you can find a compromise between the speed of your computer and the level of detail in the program. If you want the simulation to run as fast as possible, select "No small objects".



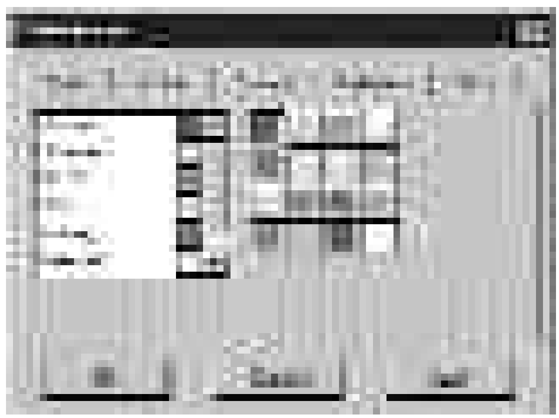
Sound

Here you can specify which sounds should be played in flight. You can prohibit all sounds in the program or only the engines noise, if it is irritating. Note that in the real Su-27 you are in a totally quiet environment, quieter than up front in a jumbo, in the cruise with ear plugs in!



Colours

If you don't like the colours used in the Mission Editor to display special symbols on the map, customise them in the Colour page of the Preferences dialog.

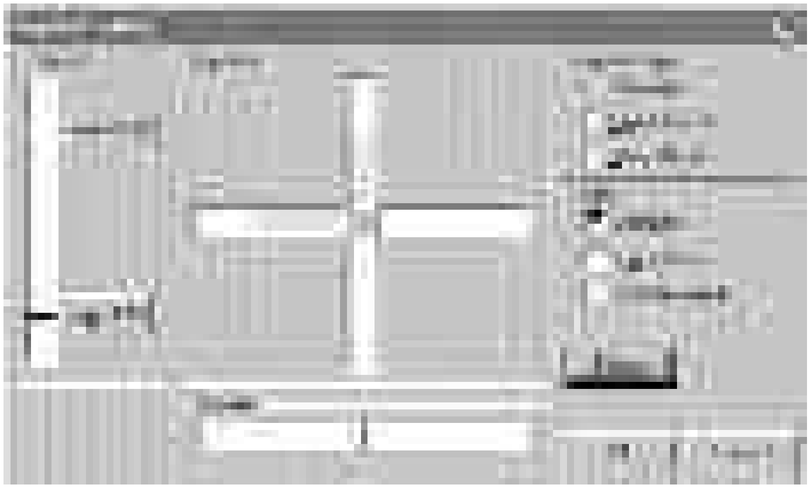


To set up a colour for all objects of a particular country, select the country name from the list and click the suitable colour button at the right. Furthermore, you can assign the colours that will be used to display selected objects and the route of your Flanker.

Joystick Setup

Regardless of whether you're running the Flanker under Windows or DOS, you'll need to calibrate your joystick, if any, from within the program. This is necessary, since Flanker works with the joystick directly and needs to know where its centre is and what the maximum deflections are.

To invoke the Joystick Setup dialog box, select **File, Program Setup, Joystick**.



At first, specify the type of your joystick. Select from Standard (2-axis, 2-button), FlightStick Pro, and Thrustmaster. The two buttons on the standard joystick have the following meanings: trigger - fire current weapon, upper button - weapons selection. All the buttons of the Thrustmaster MARK II WCS and F-16 FLCS & TQS can be reprogrammed as explained below.

After you have selected the type of your joystick, calibrate it as follows. Put the joystick in the centre and press the **Centre** button to store this position. Deflect the joystick slowly to all four sides as far as possible. Watch the colour bars move in the process.

If you have a thrust lever (or a thrust wheel) and rudder pedals, you need to calibrate them as well. Move the thrust lever forward then backwards as far as possible. Then place it in the minimum RPM position and press the **min RPM** button. Push the thrust lever forward to the maximum RPM position and press the **max RPM** button. To calibrate the rudder pedals, deflect them to both sides as far as possible then put the pedals in the central position. To save the settings press the **OK** button.

If your joystick, thrust lever or rudder pedals behave in an unexpected way, you can disable them individually in this dialog box.

Programming the Thrustmaster systems

For the owners of the Thrustmaster MARK I WCS, MARK II WCS, and F-16 FLCS & TQS in the JOYSTICK subdirectory we provide special text files, which contain standard settings for the buttons and switches. You can use these settings as is or reprogram them to suit you best.

For example, to program the MARK II buttons load the *mark2.adv* file into any text editor and proceed as described in the technical manual for your joystick. In general, the command line with a button assignment looks like this:

```
BTN {name} [{switch} {key}…]
```

where name is the symbolic name of the button on the WCS of FCS (for example, UB, HU, or 5). The switch denotes symbolic presentation of the position of the Rocker Switch (RU, RM, or RD). The key stands for the name of the key that performs the function you want to assign to the button. For example, the following line

```
BTN 1   RU Q   RM P   RD Q
```

specifies that Button 1 of the WCS should act as the **Q** key (release chaff & flares) when the Rocker Switch is in the UP (RU Q) or DOWN (RD Q) position, and as the **P** key (release the drogue chute) if the switch is in the MIDDLE position (RM P).

After you have programmed the thrust, the Rocker Switch, the coolie hat and all the buttons as needed, save the file to disk. Then load it to the Thrustmaster MARK II as described in the technical manual. To do that, you normally use the *mk2load.exe or download.exe* program which are provided with the Mark II system, for example:

```
download su27wcs.adv
```

Russian Alphabet

Russian character	Pronunciation	English equivalent
А	[a]	A
Б	[b]	B
В	[v]	V
Г	[g]	G
Д	[d]	D
Е	[je]	E
Ё	[jo]	-
Ж	[zh]	-
З	[z]	Z
И	[i]	I
Й	[j]	-
К	[k]	K
Л	[l]	L
М	[m]	M
Н	[n]	N
О	[o]	O
П	[p]	P
Р	[r]	R
С	[s]	S
Т	[t]	T
У	[u]	U
Ф	[f]	F
Х	[kh]	H
Ц	[ts]	-
Ч	[ch]	-
Ш	[sh]	-
Щ	[sch]	-
Ъ	-	-
Ы	[i]	Y
Ь	-	-
Э	[e]	
Ю	[ju]	-
Я	[ja]	-

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WHAT TO DO IF YOU HAVE A DEFECTIVE DISK

Each of our games undergoes extensive playtesting prior to its release. Through this process we hope to uncover and correct any errors in programming. Due to the complex nature of our simulations, however, some program errors may go undetected until after publication. In addition to errors in the program, there are occasionally problems with the disk itself. We experience the industry standard of approximately a 3 to 5% failure rate of duplicated disks. Before assuming that a disk is defective, make sure to check your disk drive. Up to 95% of the disks returned to us as defective will run fine on our computer systems. Often the problem is with a disk drive that needs servicing for alignment, speed or cleaning.

Should you have a defective disk, please return the disk only (keep all other parts of the game) to our Customer Support Department, along with a note describing the problem you have encountered. A replacement disk will be provided upon our receipt of the defective disk.

Should you uncover an error in the program, return both your game disk and any "save game" disks to our Customer Support Department. Please enclose a description of what was taking place in the game when the error occurred. Upon correction of the program error, we will return an updated disk to you.

Always make sure to include your name, address and daytime telephone number with any correspondence. We will do our best to see that any problems are corrected as soon as possible.

TECHNICAL SUPPORT

Should you experience any technical problems with this software, such as it failing to operate, please contact our Technical Services Department:

Address: Technical Services,
The Learning Company (UK)Ltd,
POBox 121, Crawley RH11 9YP, England.

Telephone: From inside the UK: 0870 741 6821
From outside the UK: +44 (0) 870 741 6821

Fax: From inside the UK: 0870 741 6822
From outside the UK: +44 (0) 870 741 6822

E-Mail: Uktechsupport@mindscape.com

Hours of business: 09:30 to 13:00hrs and 14:00 to 16:30hrs Monday to Friday

We regret that we cannot offer game hints and tips, as the service is provided for technical difficulties only.

Notice to the user regarding mission files generated using Su-27

1. Using the 'Mission Editor' function in Su-27, individual missions can be saved and loaded on to separate disks, transported, transmitted, exchanged and otherwise reproduced and distributed to third parties.

2. Users should note that all and any copyright and other intellectual property rights in and to Su-27 Flanker and its component parts are controlled by Mindscape and SSI pursuant to a license granted to it by the Fighter Collection Limited (collectively referred to herein as the "Rights Owners").

3. The Rights Owners hereby authorise user to save missions ("Missions") and to use same in the manner contemplated at paragraph 2 above. Notwithstanding the generality of this authorisation, however, users may not exploit Missions for any commercial purpose whatsoever.

4. Users should note that Missions, however, may be collected, collated and further exploited by Rights Owners in all and any media now known or hereafter invented and included (but not limited to) their reproduction and exploitation in all generated media and by way of hard copy.