# Lock On:™ Modern Air Combat
# Lock On:™ Air Combat Simulation

# Enhanced Manual

## Reference Manual
## Training Guide
## Recognition Guide

## Digital Aspirin Ltd & Ubisoft
## 2003

## Copy Number

# Index

# Introduction

It is indeed a pleasure to have been asked to write this introduction for what will hopefully become a trend for flight simulation games.

## Our Unique Hobby

Combat Flight Simulation games for have been in existence since the first personal computers. At one time flight sims were one of the primary entertainment applications for the personal computer. Those of us that enjoy these products share a love of several genres, be it the military, flying, speed, or the fine details and procedure of aviation brought to our screens. Whatever the reason, we all share a common interest in something that requires patience and skill as well as an understanding of the principals of flight and aerial combat. We are a unique group of enthusiasts. Instead of wanting a game that is easy to figure out and simple to operate, we demand and marvel at the complexity and fidelity of air combat. We are the "Armchair Fighter Pilots" who want to sample a bit of the thrill of strapping ourselves to a jet that is going to go into harm's way.

## Our Hobby Abandoned

Being unique has a real disadvantage. We are a niche market in an overall population that craves instant gratification and reward. Alas, our niche community has been abandoned by the traditional market for video games. The big money can now be found in first-person shoot 'em ups, "Pop Culture" licensed titles, and "simulations" that model our interpersonal relationships. The video game industry has "gone Hollywood" and there is little room in this financial juggernaut for the detail and high-fidelity that we desire. Video games are now played on your television with a console box that is easy to use and simple to configure. While I have nothing against the world of console video games, their popularity has pushed our hobby off the shelves. Combat fight simulations are not dead, but they are no longer a genre that is supported by the software industry. Fortunately publishers like Ubi Soft have supported products like *IL-2 Sturmovik* (an excellent WWII flight simulation developed by our friends at 1C: Maddox Games who are also located in Moscow*)* and, of course, *Lock On*

## The Community

The combat flight simulation community is a strange bunch. Some of the most loyal and dedicated users of any product can be found in our midst. Many of these people participate online in the various community forums and product websites. It is an international crowd with users from all over the globe sharing their passion and experiences. The majority of these people are friendly and will go out of their way to help out a fellow flight sim enthusiast. I'm pleased to have made friends all over the world through my participation online in the flight simulation community.

Unfortunately, we have our dark side as well. While the majority of users are helpful and willing to assist anyone showing an interest in our hobby, there are also those that show incredible amounts of intolerance and snobbery. These types are easy to spot in the online community. Like most human endeavours, there are always a few bad apples. They are to be avoided if possible. You'll recognize them immediately should you encounter them online.

But fear not brave user! The community remains active and vibrant. You can always count on the majority of online users to give you the answers to your questions and provide you with the latest information about our hobby. There is also an enormous amount of creativity online in the form of humor, third-party enhancements, and new missions. It is well worth your time to spend some time online with this bunch. A good place to start is the General Forum at www.lo-mac.com.

## History of Lock On

Back in 1994 an entertainment software company called Strategic Simulations, Inc. (SSI), well known for its line of wargames and fantasy role-playing games, was purchased by Mindscape, Inc. A gentleman named Jim Mackonochie, who was a Vice President for Mindscape, was able to enter into an agreement with a gentleman named Nick Grey. Nick is one of the managing directors of The Fighter Collection (TFC), which operates with a software development studio named Eagle Dynamics. Eagle is based in Moscow and at the time had a prototype simulation depicting the Su-27 Flanker jet fighter. This product became *Su-27 Flanker* and was published in 1995.

*Lock On* is the third product in a generation of combat flight simulations that started with S*u-27 Flanker* and was followed by *Flanker 2.0. T*he *Flanker* series of products introduced the flight sim community to combat aircraft flown by Russia. The staff at Eagle Dynamics is a very talented and dedicated group of professionals.

I was fortunate enough to have been a newly hired Producer at SSI when the *Su-27 Flanker* product was started. The opportunity to work on this project was something I jumped on immediately. I was working with the fine folks at Eagle Dynamics and my counter-parts at the Mindscape UK office. Following the release of this first *Flanker* product we soon created an add on product for *Su-27 Flanker* which included new missions and a major product upgrade to Version 1.5.

The sequel *Flanker 2.0* was released in 1999 by SSI. As with the original *Su-27 Flanker* product, we went on to create a major upgrade to *Flanker 2.0* that we called *Flanker 2.5*. This upgrade would be sold online and would add the MiG-29 as a user flyable aircraft. We also upgraded and enhanced the overall simulation by fixing some problems and adding new features.

*Lock On* began as a proposed add on product to *Flanker 2.0* that would feature the Russian Su-25 Frogfoot attack jet. Our original plan was to dovetail the development effort for the Flanker 2.5 upgrade into the process to create the *Su-25 Frogfoot* product. During the early planning for this next Flanker product Mindscape and SSI went through a corporate acquisition by The Learning Company. This was to be the first of several additional corporate buyouts and mergers. At the time I was an Executive Producer with SSI in charge of Combat Simulations.

We saw an opportunity to expand our original plans for a new *Flanker* product by adding a Western attack jet, the A-10 Thunderbolt II affectionately known as the “Warthog”. At the time another large publisher of combat flight simulations had cancelled their plans to feature the Warthog in a product. I must admit at this point that my personal interest in the Warthog was a major factor in my going the distance to get this aircraft included in the product. I have always had an interest for the A-10 and wanted it in our simulation very much. We obtained approval to proceed with including this unique and very popular combat aircraft into our plans.

The decision was made to create a sequel product instead of a mere add on. This new product would feature the Frogfoot and Warthog and would be called *Flanker: Attack*. Of course there would be a few more corporate adventures and The Learning Company was soon purchased by Mattel and we became a new publishing and development organization known as Mattel Interactive. The scope of the product increased at this time by the inclusion of a Western counter-part to the Su-27. Thus, the F-15C Eagle joined the ranks as another flyable aircraft in the product.

At the very end of our development efforts on the *Flanker 2.5* upgrade the future of our group was again questionable as Mattel was selling off the assets of Mattel Interactive. We were up for sale with no idea what would happen to our future products. This state of being would become a familiar one as we were soon sold to a holding company which helped maintain our existence but had plans to parcel off the assets of the former Mattel Interactive/Learning Company.

Once *Flanker 2.5* was finished we were still in a state of limbo. We came to decision to release the 2.5 upgrade for free over the Internet to ensure that the upgrade reached the users who had purchased *Flanker 2.0* in case we were forced to shut down. Several weeks following the release of the *Flanker 2.5* upgrade the entertainment product group of the former Mattel Interactive/Learning Company was sold to Ubi Soft Entertainment.

Each one of these corporate acquisitions and changes in ownership resulted in a process of evaluation to determine which products would continue and which ones would be cancelled. This resulted in major delays to the products we were working on at the time to include all the combat simulations. Some products were cancelled; others were cancelled and then resurrected. Fortunately, *Flanker: Attack* survived but it now had a new name – *Lock On*. We added some new features to include the ability to scale the product to make it more accessible to new users without taking away the more realistic aspects that veteran users desired. Of course all of this only resulted in further delays.

In late 2002 I left Ubi Soft and began working directly with The Fighter Collection and Eagle Dynamics. I was pleased to be able to concentrate my efforts on the genre and product line that I loved. Our product had suffered many delays and yet all of knew that it had great potential. We also knew that there was little competition for this type of product as modern air combat simulations were not being supported by the industry. We believed then and we still believe now that we have a product that would be popular.

## *This Manual*

My association with Mr. Nic Cole began in the late Summer of 2003 when he inquired on the official Lock On forums about the possibility of producing a hard copy manual for Lock On. I contacted him and lent my support for such an effort. I had been suggesting that a hard copy manual for Lock On be made available for separate purchase by the publisher so I was very pleased to see an effort from the community take form.

The trend in the entertainment software industry has been to eliminate hard copy manuals and move to smaller standard packaging for software products. The documentation for most products being sold now consists of a small "get started" pamphlet and a more extensive manual in "electronic format" on the game disk. This arrangement works fairly well for 99% of the games being published. It does not work well for a detailed and complex product like a combat flight simulation. I have always been an advocate of rich and detailed documentation for the products I've worked on, but the costs and resources for this type of manual were no longer something that the publishing arm was interested in devoting to a niche line of products.

Through his persistence and some backing by a few of us that really believed in the concept of a third-party manual effort, Nic Cole was able to convince Ubi Soft that this manual was a viable option. An agreement was soon reached. Nic began to gather content and enlist the help of several of us in the Lock On community to assist him in getting the manual together. We at Eagle Dynamics were delighted at the prospect of a more detailed hard copy manual. That you are now reading this is proof that a grass roots effort by dedicated and talented members of the flight sim community can achieve great things.

## *The Future*

As I write this introduction we are in the final days of development for Lock On. We are testing a Release Candidate as I type. It's been a long process to get it finished and we are very proud of our work. What about the future?

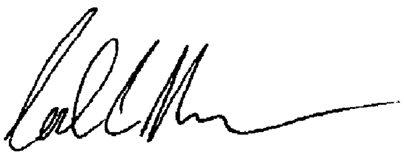
We see great potential for follow on products in the form of new aircraft to fly and new missions. We have several proposals for such products and we hope that they are forthcoming. There are also new combat simulation products on our drawing board that we hope to bring to you in the future. The future of all these products depends on the success of Lock On. The potential for these types of third-party produced manuals depends on you, the members of community. Please help promote this manual to your peers. Let them know about it and urge them to support Nic and his efforts. This will ensure that we have this type of documentation for future products.

## *Much Appreciation*

Those of us at TFC/Eagle Dynamics would like to thank several people who really made a difference. Mark "Shepski" Shepheard and Andrew "Swing Kid" Pavacic were instrumental in their assistance. We owe our dedicated external Beta Testing crew our thanks for the many hours of dedicated support. They and many others too numerous to mention here are listed in the credits and several of them have been with us since our first product. "Gentleman Jim" Mackonochie continues to be an invaluable ally and friend and we are grateful for his constant support.
T<br>
hanks also to our friend and colleague Matt Wagner at Ubi Soft for his hard work and dedicated efforts. Special thanks to Nic Cole for making this manual possible. We wish him much success in this venture and hope that it is the start of something that continues for our community and his success.

I would also like to express my deep personal appreciation for my associates Igor Tishin, Jim Mackonochie, and Nick Grey. I have always been blessed to have been working with people whom I can call friend. I am also proud to have worked with the talented staff of Eagle Dynamics. Their hard work and skill is appreciated by all of us.

Kind Regards,



Carl C. Norman<br>
Executive Producer<br>
The Fighter Collection / Eagle Dynamics

## *Manual Credits*

Nic Cole – Editor
Mark Shepheard – Training Section Editor

Lynn Gosley – Binder Design and Build Consultant

**Quality Assurance & Clearance**

Matt Wagner – Ubisoft
Charlie Barrett – Ubisoft
Carl Norman – Eagle Dynamics / The Fighter Collection

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Nic Cole
Digital Aspirin
Sheffield
November 2003

# Lock On Credits

## Eagle Dynamics

### MANAGEMENT

Nick Grey
Project Director,
Director of The Fighter Collection

Igor Tishin
Project Development Manager,
Director of Eagle Dynamics, Russia

Andrey Chizh
Assistant Development & QA Manager

Carl Norman
Executive Producer & Consultant

### DESIGNERS

Vladimir Trifonov
Terrain

Vladimir Titov
Terrain

Marina Kurdjukova
Terrain

Vladislav Kuprin
Cockpits, GUI

Alexander Drannikov
Planes

Timur Cygankov
Ships, ground vehicles

Yury Shubin
Planes

Alexander Porozov
Planes

Vyacheslav Bogdanov
Graphics effects

Denis Poznyakov
Graphics effects

## PROGRAMMERS

Valery Blazhnov
Lead Programmer

Vyacheslav Patutinsky
AI Planes

Igor Krylov
SAMs, Ships, Ground Vehicles

Alexander Matveev
Input, Sound

Sergey Chistov
Track IR, Sound

Grigory Yakushev
Graphics

Timur Ivanov
Graphics

Yury Uralsky
Graphics

Dmitry Sultanov
Graphics

Dmitry Zhukov
Graphics

Maxim Porshnev
Objects Animation

Dmitry Robustov
Terrain

Vitaly Nikityanin
Optimisation

Evgeny Dovgopoly
Mission Editor

Igor Loginov
GUI, Mission Editor

Alexey Kravetsky
GUI, Mission Editor

Alexey Vakhov
Mission Editor

Alexander Alexeev
GUI

Anton Trutce
Avionics, weapon systems

Vladimir Feofanov
Flight dynamics

Maxim Zelensky
AI Planes, Flight Dynamics

Dmitry Baikov
Internet game, Installer, GUI

Sergey Gurchev
LAN game, Track Recording

Dmitry Illarionov
MAP

## TECHNICAL SUPPORT

German Lutchak
Internet & Network maintenance

Andrey Solomykin
Flight dynamics research

Dmitry Moskalenko
Aerodynamics calculations

Denis Panchuk
Aerodynamics calculations

Alexander Komarov
Lead Tester

# UBISOFT

CEO:
Yves Guillemot

International Production Director:
Christine Burgess-Quemard

International Content Director:
Serge Hascoet

## LOCALIZATION

Worldwide Localization Manager:
Coralie Martin

Localization Project Manager:
Loic Jacolin

## PRODUCTION

VP of product development:
Bret Berry

Executive Producer:
Tony Van

Producer:
Matt Wagner

Associate Producer:
Marc Fish

Data Management International Service:
Guenaele Mendroux
David Picco
Benoit Maury-Bouet

## MARKETING

US Marketing Director:
Tony Kee

US Group Manager:
Karen Conroe

US Brand Managers:
Tena Lawry
Sarah Berridge

EMEA Marketing Director:
Florence Alibert

EMEA Group Manager:
Gabrielle Zagoury

EMEA Brand Manager:
Yannick Spagna

International Marketing Team:
Sylvaine Gomez
Andreas Balfanz
Doug Mc Conckey
Christian Born
Javier Montoro
Pim Hofmeester
Nick Wong
Soren Lass
Yannick Theler
Bertrand Chaverot
Vanessa Leclercq
Zhou Hui Bo

## PUBLIC RELATIONS

US PR Manager:
Clint Hayashi

## TEST

QA Manager:
Eric Tremblay

Assistant Manager:
Eric Audette

Lead Tester:
Emmanuel-Yvan Ofoe

Testers:
Alain Chenier
Allen Tremblay
Antoine Drouin
Antoine Thisdale
Eric St-Jean
Frederic Laporte
Louis-Phillipe Brissette
Marc Brouillette
Marc-Andre Proulx
Martin Shank
Martin Tavernier
Mathieu Larin
Mathieu Laurin

Pascal Gauthier
Patrice Cote
Pierre Boyer

Compatibility Test:
David Levesque
Jason Alleyne

External Beta Testers:
Oscar Garcia Minguillan
Jose Benito
Francisco de Ascanio
Carlos Garcia Pineiro
Jim Campisi
Jeff Streeter
Gene Buckle
Leonardo Rogic
Goran Ivaz
Robert Borjesson
Juan Andres Hermoso Franco
Guillaume Leleve
Manuel Silveira
Dan Crenshaw
James Rhodes
Moodie Coretti
Chad Matthew Griffin
Michael Scampini
Lou Mayers
Pascual Malonda
Ivan San Primitivo
Alejandro Lorenzo Gallego
Francesc Basullas
Domingo Silanes
Jose Luis Barrero
Jose Ma Catena
Santiago Cerezo
Fernando Fernandez de Benito
Luis Rivas
Roberto Seoane
Ian Boys
Andrew Peter Pavacic
James Hallows
Chris Picco
Aaron Watson
Igor Harlukov
Anton Stepanov
Arkady Lalayants
Denis Chumachenko
Alexander Saigushkin
Alexey Egorov
Danila Pyatkin
Kirill Dzyuba
Vladimir Vorobiev
Alexander Tulin
Alexey Larin
Vagan Grigoryan
Sergey Vertelev
Alexey Prokopchuk
Igor Anisimov
Andrey Serov
Mikhail Sapronov
Alexander Gorbachenko
Ruslan Ilyin

## GAME MANUAL

Reference Manual:
Tom Basham

## SOUND

Music:
Marshall Crutcher - Perfect Score

Voice recordings:
Charles DeVries Multimedia

## SPECIAL THANKS

Thomas Desaveines
for aircraft textures

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for F-15C consultation

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for A-10A consultation

Christopher Andreychik
for A-10A consultation

Andy Bush
for A-10A consultation

Joe Hodges

for A-10A consultation

Glenn Davis
for military aircraft consultaion

Sergey Trukhan
for Su-25 and Su-27 consultation

Alexander Degtyaryov
for MiG-29 and Su-27 consultation

Daniil Tuseev
for MiG-29 and Su-27 consultation

Nikolay Isaev
for military consultation

Andrew Peter Pavacic
for single missions
and Pilot Log Book consultation

Jan Slegers
for Pilot Log Book consultation

Michael Larsen
for Pilot Log Book consultation

Manuel Fossa
for Pilot Log Book consultation

George Gachaleishvili
for Pilot Log Book consultation

Roy van Versendaal
for Pilot Log Book consultation

Francisco de Ascanio de la Vega
for Pilot Log Book consultation

Ertugrul Ozmen
for Pilot Log Book consultation

Dominik Merk
for Pilot Log Book consultation

Chris Janssens
for Pilot Log Book consultation

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for Pilot Log Book consultation

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# Printed Manual Errata

**Page 5. Starting the game.** A "Show Replay" (SHOW)" button has been added to the Navigation Bar on the Main Menu. Once selected, you can use the browser menu to select Track Files. Once selected, press the Start button to begin playing the Demo track.

**Page 5. Starting the game.** A "Network Play (NTW)" button has been added to the Navigation Bar on the Main Menu. This allows you to directly access the Network play menus from the Main Menu.

**Page 6. Starting the game.** The Back/Fwd Button has been removed from the Main Menu.

**Page 9. Graphics.** We suggest setting VISIB RNG and SCENES to High and WATER to Very High if you have top-end computer.

**Page 9. Graphics.** An option to toggle civilian road and rail traffic on and off had been added to the Graphics settings. From the CIV TRAFF button, you can select Yes or No.

**Page 9. Graphics.** An option to toggle the advanced haze effect as been added to the Graphics settings. From the HAZE button, you can choose Basic or Advanced.

**Page 9. Graphics.** As option to choose water detail level has been added to the Graphics settings. From the WATER button, you can choose Low, Medium, High, or Very High.

**Page 9. Graphics.** An option to disable engine heat blur has been added to the Graphics settings. From the HEAT BLR button, you can select On or Off. Note that game smoothness can at times be negatively impacted if Heat Blur and FSAA are used simultaneously.

**Page 9. Graphics.** The FREQ selection has been removed.

**Page 10. Audio.** If you feel the engine and other cockpit sounds are too quiet, you can use the COCKPIT slider to increase the volume. You can also increase the ENGINES level to make the engine sound louder in the cockpit.

**Page 10. Audio.** "Betty in Russian" has been changed to "Russian Voices." This is because you can now hear all radio communications in Russian when flying a Russian aircraft. If you select the German MiG-29A, the Betty voice will be in German.

**Page 11 and 45.** Difficulty. Two additional buttons have been added to the My Plane box. The G-EFFECTS button allows you to disable black-outs and red-outs when under extreme G. The PADLOCK button allows you to enable or disable the use of the padlock option.

**Page 11 and 46.** Difficulty. The AWACS view has been renamed the MAP view.

**Page 11. Difficulty.** Within the Simplification box is a button entitled SET GLOBAL. When this button is ON, the player's difficulty settings and the Scene setting for Graphics will be used for all missions. If however the button is not on, the difficulty and scene settings will be used when the mission was created.

**Page 11. Difficulty.** When simplification is changed between imperial and metric, this only applies to measurements used in the Mission Editor. It does not apply to the flight portion of the game.

**Page 12. Cockpit.** The G-Effects setting has been moved to the Difficulty page.

**Page 18. Multiplayer.** After pressing the NTW button, a window that allows you choose either a LAN or Internet game will be displayed now. You must make this decision before preceded to Host or Join a multiplayer game.

**Page 19. Multiplayer.** Protocol section has been removed from LAN network connection options.

**Page 19. Multiplayer.** The Ubi.com button only applies to an Internet game. This button has been removed from the LAN screen.

**Page 18.** Multiplayer. The multiplayer description in only accurate for when LAN play is selected. Internet play uses an entirely new system of connection. When you enter an Internet game, there will be a two-position dial near the top of the screen. One setting is labeled Player and the other Connect.

When set to Player, you can enter your name in the NAME field. Press the enter key once you have typed in your name.

When set to Connect, you can enter your Host or Client connection properties. If Network Settings button is set to SERVER, then you are acting as the Host and you can determine PORT number, connection speed, and password. You can also set global setting such as session title, maximum number of players, and game mode in the Game Settings screen. If set to Client, you can enter the SERVER IP number and the required password if needed.

Once the SERVER and CLIENTS have entered the required data, they can press the START key to proceed.

After the SERVER presses the START key, they will be brought to the OPEN mission screen. After selecting the desired mission, press the MAP key to return to the Internet interface.

Once all players have reached the Join Game screen, they can select their coalition. If no planes are available in a coalition, the JOIN box will be greyed out. Upon selecting a valid coalition, press the SELECT button in the top / left portion of the screen to select an aircraft. Simply click on the aircraft you wish in the Select Plane list. If you wish to change coalitions, you can click the Coalitions button on the top menu bar.

Once players have selected their aircraft, the FLY button can be pressed to start the mission. Note that each player must press the FLY button in order to enter the mission.

**Page 22.** Multiplayer. It is not possible for clients to in-flight refuel during multiplayer games.

**Page 22.** Multiplayer. Only a single player can be assigned to take off from the Kuznetsov aircraft carrier. Adding more than one aircraft will cause over-lapping.

**Page 22.** Multiplayer. When flying an Internet game, each player must be assigned an individual Group when creating the mission. You cannot assigned players to separate Flights within a Group.

**Page 22.** Training. Advanced Training has been renamed Top Gun.

**Page 22.** Training. Select the EXIT button in the lower / left portion of the screen to exit the Training screen.

Page 22. Training. In order to avoid problems with the training missions, please mind the following:
- Resolution to 1024x768
-Cockpit view angle set to 60(default)
-Mouseview off
-Mirrors off
-Russian HUD setting
-Do not press any key but "S" to pause and un-pause while viewing

**Page 25.** Log Book. The pull down menu to view general statistics has been removed.

**Page 26.** Log Book. To exit the Log Book, press the Exit button in the lower / left portion of the screen.

**Page 29.** Easy Radar. When setting the display mode to ALL, all ground, surface, and naval units will be displayed on the screen.

**Page 30.** Mission Editor. From the File selection on the Menu Bar, Merge is also available. This allows two separate missions to be combined into a single mission.

**Page 30.** Mission Editor. From the View selection on the Menu Bar, Crimean View has been changed to Actual Size view. Additionally, Object View and Region View have been removed.

**Page 30.** Mission Editor. From the File selection on the Menu Bar, Record AVI has been added. After selecting a track file, this option can be enabled and allow the player to convert a track file into an AVI video. To create an AVI file, please follow these steps:

1- From the Mission Editor, select the desired Track file you wish to convert to an AVI file.
2- Once selected, select RECORD AVI from the File pull down.
3- A new dialog screen will be presented in which you can select Start and End time of recording, the compression Codec and quality level, the name you wish to save the AVI as, and the frame rate you wish the AVI to play back as.

Once you have made your selections, press the Start button. Lock On will then replay the Track file frame by frame until completion. Note that this can be a long process of the recording length or frame rates have been set high.

After the video had been recorded, the sound pass will automatically be recorded. This will play back in real time, but you will only hear the mission being played out. For proper AVI sound recording, ensure you have WAV as your Windows sound recording device.

**Page 30.** Mission Editor. From the File selection on the Menu Bar, Loop track can be selected to continually loop the selected track file.

**Page 44.** Mission Editor. Regarding cloud cover, when the Density is set to 5 or higher, the precipitation drop down becomes active. Selections include None, Rain, and Thunderstorm. If however the Season is set to Winter, the precipitation options will be None, Snow, and Snow-storm
.

**Page 45.** Mission Editor. Creating a Campaign. Creating a user-created campaign is a simple process that uses the fundamentals of creating a single mission within the Mission Editor. To get started, enter the Mission Editor and press the CAMP button on the left portion of the screen.

You will now be presented with the Campaign creator / editor. To create a new campaign, follow these steps:

1- Select the countries that will take part in the two coalitions. From the Coalitions button at the top of the screen, place at least one country in the Red and Blue coalitions. Press OK when complete.
2- In the top Title box, enter the title of the campaign you are about to create.
3- Each mission is composed of a generated stage that you create. In the Stage box, enter the name of the first stage in the Title box. In the Description box, enter the text briefing that the player will read.
4- Create the stage as you would a normal single mission. However, all the static objects you place in the first stage will automatically be carried over to later missions.
5- When you are ready to create the next stage in the campaign, forward the stage number to 2 and create you next mission. You can keep adding stages this way until you have all the stages you wish in the mission.
6- To enter the text that the player will read when he or she has finished the campaign; select the Results button and enter the campaign debriefing text.

# *TROUBLESHOOTING & TIPS*

Increasing frame rate and performance

It's always a good idea to defragment your drive for better performance. Use the Windows Disk Defragmenter in Accessories/System Tools to defragment your drive.

Ensure that you have the very latest drivers for you video card. You can usually obtain updated drivers on the support website of your card's manufacturer. The manufactures of the more popular video cards often update their drive sets.

Ensure that you have DirectX 8.1 or higher installed on your system. DirectX 9 is included as part of the Lock On installation routine. The setup for DirectX 9 is located on the Lock On CD. Many of the "MX" type of cards are older video chips that are use more memory and are then marketed as newer cards, but many of them do not support 8.1 or higher. Older video cards MAY run Lock On but without all the effects and the performance will be questionable. Your video card MUST support DirectX 8.1 or higher. NOTE: Having the correct version of DirectX installed on your system alone is NOT the answer. Your card MUST also be compliant with 8.1 or higher. Older cards will most likely NOT meet this requirement.

Shut down programs running in the background (Virus Scanners, Firewalls, etc.) Zone Alarm is known to cause problems when trying to use the Options menu as reported by several Lock On Demo users. If you choose to run other applications in the background you WILL have a lower performance with Lock On. There are several utility programs such as Enditall and others you can obtain on the Internet that can assist you in shutting down other applications.

Lock On will run slower if you have all the graphics and effects settings on their highest settings. This is particularly noticeable with minimum spec computers and hardware. Your "mileage" may vary, but to get all the effects and have good performance you will need top of the line equipment. Lock On can be run at lower settings and still be a very enjoyable simulation experience, but the high end and the future of hardware were primary considerations when we designed this product and its graphics effects.

Performance will also be affected by the size and content of missions. Large missions with many vehicles, missiles, aircraft, and radars will have a noticeable affect on performance and frame rates. Try adjusting the settings in the Options – Graphics screen to optimize for your best performance for your hardware.

There are quite a few different options for graphics and cockpit settings in Lock On the more of them you use and the higher the quality you select then the lower your performance will be when running the program. While we would like to provide you with an optimum settings profile, it is impossible to give a profile that will be optimum for all the many different hardware configurations that users possess. You are going to have to experiment with your individual settings to see what works best for you and what options you feel are worth the hit in performance. As each of us have our own personal preferences for graphics and effects, these aspects only add to the difficulty in our providing a standard profile. Again, your preferences and personal tastes will have to be factored into how you set up the features in Lock On.

The settings for WATER, VISABLE RANGE, and COLOR have a big impact on frame rate.

The WATER effects are a big frame killer even if you are not flying over water and have the setting on high, your performance will be lower. Set WATER to Low if you do not have a high performance system and/or video card.

VISABLE RANGE will also take a lot of your system's performance. Unless you are using a high resolution, there really is no big difference between the Medium and High settings for this option. Medium appears to be optimum. Your results may differ depending upon your hardware.

The HEAT BLUR effect is NOT compatible with your video card anti-aliasing features turned on and will create a conflict that will greatly affect performance and frame rate. If you want HEAT BLUR effects you need to turn off your anti-aliasing settings. Note: The HEAT BLUR effects do not appear for all aircraft (A-10 for example) and will not appear for aircraft if they are travelling at high speeds.

The COLOR setting should really be set to 16 bit as the advantages of 32 bit are only for the very top end video cards. The advantage of 32 bit will most likely be noticeable with video cards that will be hitting the market in the near future. For now it is recommended that you stick with 16 bit. If you do use 32 bit, ensure that your Windows Desktop is also set for 32 bit.

Cockpit Mirrors are nice to have, but they can rob you of performance. They are not essential, particularly for air-to-ground. Turn them off unless you really feel that you need them. You can also lower their resolution to save on performance.

### Joysticks, Throttles, Rudders, and other devices

You may need to manually adjust your joystick, throttle, and rudders using the Options – Input menu.

The default settings for Lock On may not match your particular input devices. Go to the Options section and set the select knob to INPUT in the upper right hand corner of the Options screen.

In the upper left hand corner there is a toggle switch showing BUTTONS or AXIS, click on this so that AXIS is selected and then select the pull-down box window so that your particular joystick is selected instead of KEYBOARD or MOUSE.

In the BUTTONS MAP text box below on the left will be a list of input areas and their corresponding inputs (PITCH, ROLL, RUDDER, THRUST, etc.) and their respective axis or rotator. To ensure your equipment is configured properly select each one and then hit the CHANGE button to upper right. A CAUTION dialog box will appear with a blank entry for an Axis input. When this box appears move the appropriate device you want to set. The proper axis or rotator will appear in the text box. Hit OK and you have set the device properly in Lock On.
NOTE: This section also provides you the ability to configure dual or split throttles to control two-engine aircraft if you have such an input device.

In the RESPONSES section of the INPUT screen there is a graph showing the response profile for each device. It is recommended that you select your RUDDER in BUTTONS MAP and then flip the switch in RESPONSES from SLIDER to AXIS. This will display the response curve for your RUDDER.

Often the rudder input devices continue to “pull” to one side. This will cause your aircraft to roll or yaw to one side. Configuring your rudders with a bit of a “dead space” will prevent your aircraft from rolling or pulling to one side. Do this by selecting the RUDDER in the BUTTONS MAP area and then moving the D-ZONE slider a small amount to the left. You will notice a flat line appear in the middle of the response curve. This will create a dead space at the centre of your rudder that will prevent rudder inputs while your rudder is in the center position.

It is also recommended that you increase the curve by placing the SHIFT slider in the middle position of the slider giving the rudders a smooth response curve on both sides.

There is also a selection on this screen that will allow you reverse (invert) the directions of your input devices.

## *Trim and Control*

Several of the aircraft, the MiG-29 in particular MUST be constantly trimmed or your control inputs will not be as effective. Read the section on trim and consult the appropriate Tutorial Mission to learn how to trim the aircraft. ALT-T will neutralize your trim settings.
NOTE: Airspeed changes also affect trim settings. Be sure to adjust trim after coming out of Autopilot.

### Audio Adjustments

If you are having choppy or distorted sound, turn Hardware Acceleration OFF in your DirectX Sound Settings.  To do this, run the DirectX Diagnostics Tool (C:\WINDOWS\system32\dxdiag.exe), select the SOUND tab, and turn off Hardware Acceleration with the slider.  Even if you do not have distorted sounds, many users of the Demo have reported better performance with Hardware Acceleration turned off.

If you want more ambient sounds in the cockpit you will need to adjust your audio volume settings in the Options – Sound screen.  Adjust the sliders for the various sound effects to the levels you prefer.  If you like to hear the engines and gun fire from the cockpit then you should increase the ENGINES and COCKPIT sliders to higher.  100% for COCKPIT will give you both engines and gun sounds.

As with the graphics settings, the volume of the various sounds in Lock On is an individual taste.  You need to experiment with the settings to obtain the sound levels you desire.

## Engaging Targets with Weapons

Familiarize yourself with the proper way to configure your aircraft for combat modes.  The weapons will not fire unless you configure your aircraft to the proper combat mode.  The default mode is Navigation when you first start a mission.  The weapons will not fire in Nav mode.

## Taking Screenshots and Recording Videos

Screenshots can be made by hitting the PrtScn (Print Screen) button.  Each time you hit this button a screenshot will be created and saved to the Lock On Screenshots subdirectory with a sequential naming convention.  If you wish to remove the information bar for exterior views hit the “Y” key twice to turn off the bar.  Hitting “Y” again will toggle the bar back on.

## Key Input Changes

1-Cockpit camera discrete steps have been implemented with Ctrl - Keypad 1-9 or Ctrl - Joystick hat. Alt-Z toggles between snap modes (to return or not to return camera tacitly). The discrete steps are configurable in the Config/View/View.cfg file.

2- Ctrl-Keypad 5 action has been changed to Alt-Keypad 5 for F11 view.

3- Shift-F11 trains/cars toggle has been added for Ctrl-F12 view.

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# INSTRUCTION MANUAL

# CONTENTS

# AIRCRAFT INTRODUCTION

The old adage, "Use the right tool for the job," applies to air combat as much as carpentry. Aircraft missions, such as air superiority, close air support, deep strike, etc., generally have conflicting requirements. Heavy armor that protects a pilot while engaging an enemy AAA site is a serious disadvantage in a dogfight. Success in the air requires a thorough understanding of each aircraft's strengths and weaknesses. The following section identifies each aircraft flyable by the player and summarizes its combat role.

## 1.1 F-15C "Eagle"

The F-15C "Eagle" has often been labeled the greatest fighter aircraft in the world. Designed to counter the exaggerated capabilities of the Soviet MiG-25 "Foxbat," the F-15 has been the backbone of U.S. air defense for three decades. The F-15C, equipped with improved avionics and weapons over the original F-15A, has scored over 100 air-to-air victories in the service of Israel, Saudi Arabia, and the U.S. without suffering any losses.

The F-15C rules the Beyond Visual Range arena (BVR). No slouch in a dogfight, the F-15C excels at finding targets, positively identifying them as hostile, and engaging them with AIM-120 AMRAAM and AIM-7M missiles before the enemy can respond.

The Eagle is somewhat restricted in the close-in dogfight. The AIM-9 Sidewinder, a reliable weapon that has soldiered on since the 1960's, does not have the high off-boresight capability of recent Russian heat-seeking missiles. Eagle drivers should generally favor the higher-speed "energy fight" in favor of the low-speed turning duel, especially against nimble adversaries.

**Length:** 63′ 9″

**Height:** 18′ 8″

**Wingspan:** 42′ 10″

**Speed:** Mach 2.5+ at sea level

**Ceiling:** 65,000′

**Max. Takeoff Weight:** 68,000 lbs

## 1.2 A-10A "Thunderbolt II"

Very few address this aircraft by its given name of "Thunderbolt II." Instead, its unusual appearance earned it the moniker "Warthog," and often simply "the Hog." Designed as a Close Air Support (CAS) platform to counter the massive quantities of Soviet armor during the Cold War, the Hog is heavily armored and carries an impressive weapon load, including a deadly 30mm anti-armor cannon. Efforts to retire the A-10 from active duty began gaining momentum, but fell by the wayside after the aircraft's stellar performance during the 1991 Gulf War and the 2003 Operation Iraqi Freedom.

The A-10 was intended to fly low, using the terrain to mask its presence from enemy Surface-to-Air Missiles (SAMs). Low flying, however, places the aircraft in the heart of the Anti-Aircraft Artillery (AAA) engagement zone. Therefore, the aircraft is heavily armored, including a "titanium bathtub" which surrounds the pilot. When the threat of SAMs has been reduced, the A-10 generally flies missions at medium altitudes, placing it safely out of the reach of AAA guns.

The sub-sonic A-10 can carry AIM-9 Sidewinders for self-defense, but should avoid dogfighting. It carries an impressive air-to-ground weapon load, but lacks the power for a sustained fight against a dedicated air-to-air platform. When confronted by an enemy fighter, the Hog pilot should use the A-10's impressive turn rate capability to point the nose (and the dreaded 30mm cannon) at the attacker. When the attacker overshoots, unload and extend until the attacker makes another pass, and then use another maximum-rate turn to point the nose back at the adversary.

**Length:** 53′ 4″

**Height:** 14′ 8″

**Wingspan:** 57′ 6″

**Speed:** Mach 0.56

**Ceiling:** 45,000′

**Max. Takeoff Weight:** 51,000 lbs

## 1.3 Su-25 "Frogfoot"

The Su-25 Frogfoot bears little resemblance to the U.S. A-10, but was designed for a very similar Close Air Support (CAS) ground-attack mission. The Su-25 was built to operate near the battlefront from rough, "unimproved" airstrips, and can carry a kit with tools, spare parts, auxiliary power supply, a pump for manual refueling, and other "self-deployment" supplies. It carries a wide variety of weapons for missions, including anti-radar, runway denial, and tank killing.

The fortified cockpit and armored canopy helps protect the pilot from AAA and small-arms fire while engaging targets at low altitude. Flying low, the Su-25 hunts down mobile targets, pops up, delivers its weapons, and dives back behind the terrain. The Frogfoot may arguably be the most powerful ground-attack aircraft in Eastern inventories.

The Su-25 is not intended for dogfighting, though. Its primary defense against patrolling flights is simple avoidance. When engaged, the Su-25 should operate at extremely low altitude, which hampers enemy fighters' ability to dive toward it. Using available terrain, the pilot should turn to face oncoming threats.

**Length:** 50′ 11″

**Height:** 15′ 9″

**Wingspan:** 47′ 11″

**Speed:** Mach 0.8 at sea level

**Ceiling:** 22,965′

**Max. Takeoff Weight:** 38,800 lbs

## 1.4 Su-27 "Flanker B"

The Su-27 Flanker and its descendants are some of the most impressive and capable fighter aircraft in the world, designed to beat the vaunted F-15. Born in the waning years of the Cold War, the Flanker did not have an easy life. The initial design suffered serious problems. Then, the breakup of the Soviet Union hindered its deployment, denying it the opportunity to prove itself as the world's greatest aircraft.

The Su-27 is tailored for air-to-air combat, not air-to-ground. Armed with the R-27 (AA-10) Alamo missiles, the Flanker has an impressive BVR capability. Meanwhile, the helmet-mounted sight and the high off-boresight R-73 (AA-11) Archer heat-seeking missile, coupled with the Su-27's high thrust and sustained turn capability give the aircraft a powerful edge in a knife fight. High-AOA maneuvering helps the pilot point his weapons at the enemy. Finally, its large fuel capacity keeps it in the fight well after most Western aircraft are running on fumes. It carries as many as ten air-to-air missiles, giving it an impressive "punch."

Detractors criticize the Su-27's avionics and cockpit layout, citing limited ability to track/engage multiple targets, high reliance on GCI control, and high pilot workload, but its passive Electro-Optical System (EOS) lets it find and engage targets without any radar signals (which can warn the target). Debate continues on whether high-AOA maneuvers (such as tail slides and the famed "Cobra") are useful combat tactics or merely impressive air-show routines.

**Length:** 71′ 11″

**Height:** 19′ 5″

**Wingspan:** 48′ 2″

**Speed:** Mach 2.35 at sea level

**Ceiling:** 59,055′

**Max. Takeoff Weight:** 72,750 lbs

## 1.5 Su-33 "Flanker D"

Originally named the Su-27K, this descendant of the Su-27 was specifically designed to operate from Soviet versions of super aircraft carriers. Equipped with canards for improved takeoff and landing performance, the first Su-27K made its maiden flight in 1985. The tail cone was shortened to reduce the risk of tail strike during high-AOA carrier landings, but also reduced the space available for defensive countermeasures (including chaff and flare dispensers). Whereas the Su-27 was tailored as an air-to-air interceptor, the Su-33 is a multi-role aircraft (a necessity of carrier-based aviation operating far from home bases). The Su-33 retains, to a large extent, the avionics and cockpit of the basic Su-27.

**Length:** 69′ 6″

**Height:** 19′ 4″

**Wingspan:** 48′ 2″

**Speed:** Mach 1.14+ at sea level

**Ceiling:** 55,250′

**Max. Takeoff Weight:** 66,000 lbs

## 1.6 MiG-29A "Fulcrum A" and MiG-29S "Fulcrum C"

Western observers often conclude, inaccurately, that the Su-27 and MiG-29 were born of a single design program, which copied the U.S. Navy's F/A-18, no less. Indeed, the Su-27 and MiG-29 look quite similar, and some observers cannot readily tell the two aircraft apart, despite the MiG-29 being substantially shorter than the Su-27. Both the Su-27 and MiG-29 design teams reportedly worked with common research data and drew common design conclusions. The MiG-29 was much more widely exported than the Su-27, serving in many Warsaw Pact air forces, several of which have since joined NATO (bringing their Soviet-made MiG-29s with them).

The MiG-29 originally shared most of its avionics suite with the Su-27 (including the radar, the Electro-Optical System (EOS), and the helmet-mounted sight), but was designed as a short-range fighter, not an interceptor. The EOS lets the Fulcrum search for, track, and engage targets without emitting tell-tale radar signals. Being smaller, it doesn't carry as many missiles as the Su-27, but its high-AOA maneuverability, coupled with the R-73 (AA-11) Archer high off-boresight, heat-seeking missile, and helmet-mounted sight makes the MiG-29 a deadly dogfighter. The slow-speed turning fight is the MiG-29's preferred arena where it can use its high-AOA capability to point its weapons at a floundering target. The newer MiG-29C includes the medium-range R-77 (AA-12) Adder missile and an internal radar jamming system.

As with the Su-27, critics cited weak avionics and poor cockpit design as weaknesses of the MiG-29A. The later MiG-29S (Fulcrum C), though, incorporated numerous improvements, including better defensive countermeasures and increased fuel capacity. The MiG-29 reportedly requires a significant amount of maintenance, especially the engines. German MiG-29As (inherited from the East when Germany was re-unified) have had their engine performance "tuned down" somewhat to preserve engine lifespan. Obtaining spare parts continues to be a concern for former Warsaw Pact nations.

Russian forces in LOMAC employ the MiG-29A and MiG-29S, while German forces in NATO operate only the MiG-29A.

**Length:** 56′ 10″

**Height:** 15′ 6″

**Wingspan:** 37′ 3″

**Speed:** Mach 2.3 at sea level

**Ceiling:** 55,775′

**Max. Takeoff Weight:** 40,785 lbs

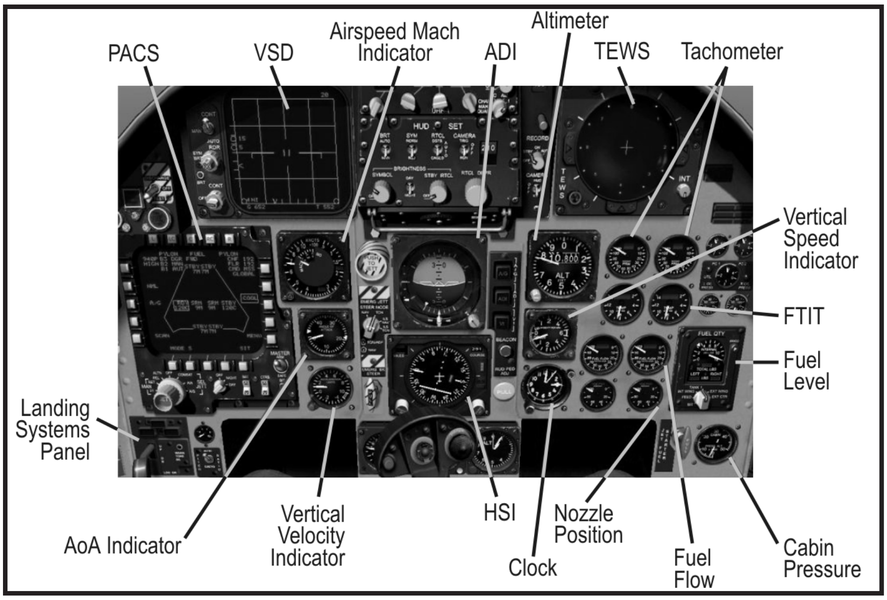
# AIRCRAFT COCKPITS

Each aircraft's cockpit is tailored for the role it performs. Although all cockpits share certain instruments, such as an airspeed indicator, an attitude indicator, engine indicators, etc., cockpit design philosophies have changed dramatically over the years. Furthermore, Eastern and Western aircraft designers often take different approaches to solving common problems. As a result, cockpit layout varies greatly from aircraft to aircraft.

In this chapter, we'll examine each aircraft's cockpit and instrumentation. You'll need to familiarize yourself with the cockpit layout for each aircraft type you intend to fly.

## 2.1. F-15C Eagle Cockpit

Although the F-15C Eagle retains a nominal air-to-ground capability, it is strictly an air-to-air superiority fighter today. Consequently, its cockpit is tailored around the radar display and threat warning display, which are situated just below the HUD. The lower section of the instrument panel focuses on aircraft attitude, engines, and storage management.




The F-15C Cockpit

### 2.101 Vertical Situation Display (VSD)

The VSD

The Vertical Situation Display (VSD), otherwise known as the "radar display," dominates the instrument panel's upper-left corner. The VSD shows a top-down view of the airspace ahead of the aircraft, highlighting target aircraft detected by the radar. Full details of radar operation and VSD symbology appear in the "Sensors" chapter.

### 2.102 Tactical Electronic Warfare System (TEWS)

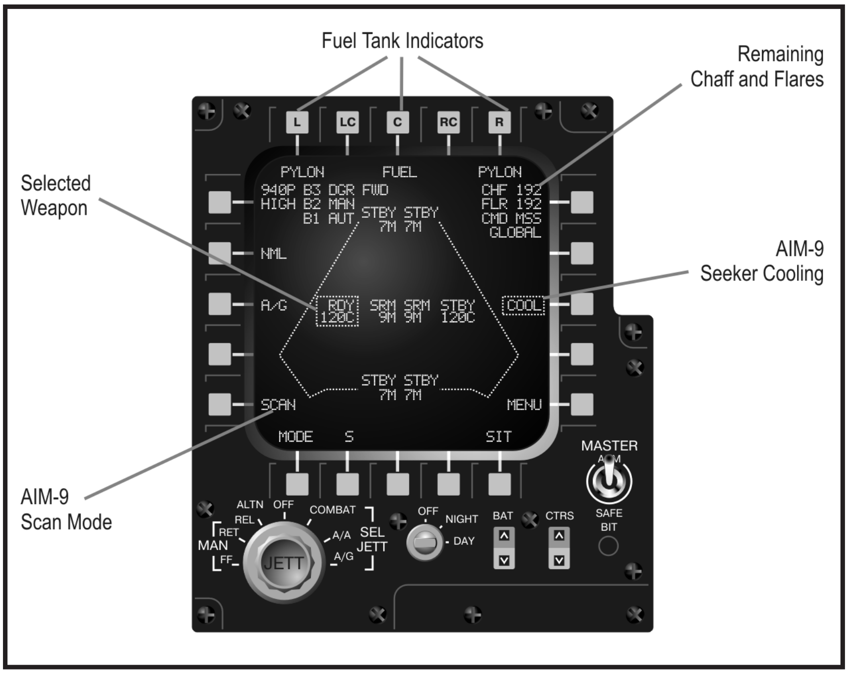
The TEWS

The Tactical Electronic Warfare System (TEWS), located in the upper right of the instrument panel, detects radar emissions (from other aircraft, surface-to-air missile launchers, etc.). It categorizes the information it detects and displays clues about the direction and type of emitter. Full usage and symbology details appear in the "Radar Warning Receivers" chapter.

## 2.103 Programmable Armament Control System (PACS)

The Programmable Armament Control System (PACS), located in the lower left of the instrument panel, is a multipurpose display that provides storage (fuel, weapons, chaff, and flares) management.

The top edge of the PACS display shows the number of loaded external fuel tanks. The positions L, C, and R indicate the status of the left, center, and right pylons, respectively. When a fuel tank is loaded, the word "FUEL" appears beneath the pylon indicator. When a tank is not loaded, the word "PYLON" appears.




Fuel Tank Indicators

The left side of the PACS display shows two indicators. The uppermost button shows the current firing rate of the 20 mm cannon. HIGH indicates 6,000 rounds per minute; LOW indicates 4,000 rounds per minute. The number directly below the rate of fire indicates the quantity of 20 mm rounds remaining. When fired, the counter decrements in units of 10.

The SCAN indicator in the bottom-left corner will be highlighted with a box when an AIM-9 missile is selected and operating in SCAN mode. See the "Weapon Usage" chapter for full details on using SCAN mode.

The right side of the PACS display indicates the defensive stores (chaff and flares) remaining, along with weapons status. The CHF and FLR displays in the upper right indicate the number of chaff and flares, respectively. The F-15C can carry up to 120 chaff rounds and up to 60 flares.

The COOL indicator along the right edge of the PACS display indicates the overall weapons status. With the Master Arm switch in the ARM position, a box appears around the word "COOL," indicating weapons are ready. The box disappears when the Master Arm switch is in the SAFE position.

The center of the PACS display shows the loaded weapons and their status. There are eight weapon stations, four on the fuselage and two on each wing. Air-to-air missiles appear in two categories: AIM-9 variants are classified as "Short-Range Missiles" (SRM), while AIM-7 and AIM-120 variants are classified as "Medium-Range Missiles" (MRM). The status for each station shows two lines based on the selected weapon type:

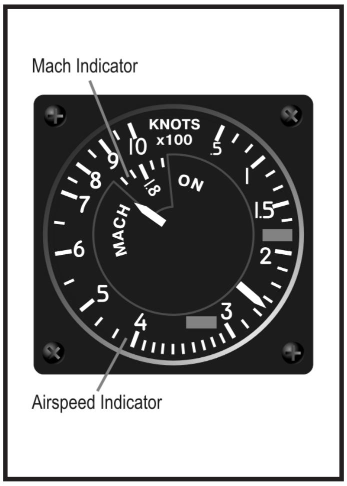
- When an MRM is selected: RDY appears above the selected weapon. STBY appears above all other medium-range missiles. SRM appears above all short-range missiles.
- When an SRM is selected: RDY appears above the selected weapon. STBY appears above all medium-range missiles. SRM appears above all other short-range missiles.

The following table illustrates the abbreviations used for each missile type:

| Abbreviation | Missile | Range |
|---|---|---|
| 7M | AIM-7M | MRM |
| 120C | AIM-120 | MRM |
| 9M | AIM-9M | SRM |

## 2.104 Airspeed/Mach Indicator

Located next to the PACS, the airspeed/Mach indicator shows the Calibrated Airspeed (CAS) and Mach number. The fixed airspeed scale, graduated from 50 to 1000 knots, and a rotating Mach number scale (synchronized so their correct relationship is shown at all altitudes) allow a single pointer to indicate both readings. The Mach number shows above 200 knots.




Airspeed / Mach Indicator

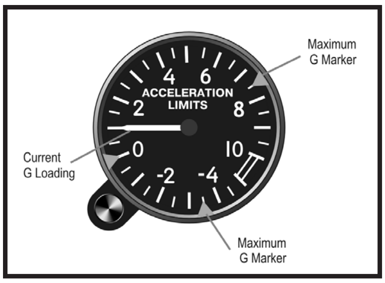
## 2.105 AOA Indicator

Located below the airspeed/Mach indicator, the AOA indicator displays the current Angle Of Attack in units from 0 to 45. The units are calibrated against the F-15C's normal flight envelope – a single unit does not equate to a single degree of pitch. An index mark is set at the approximate optimum landing approach AOA (20 to 22 units).


AOA Indicator

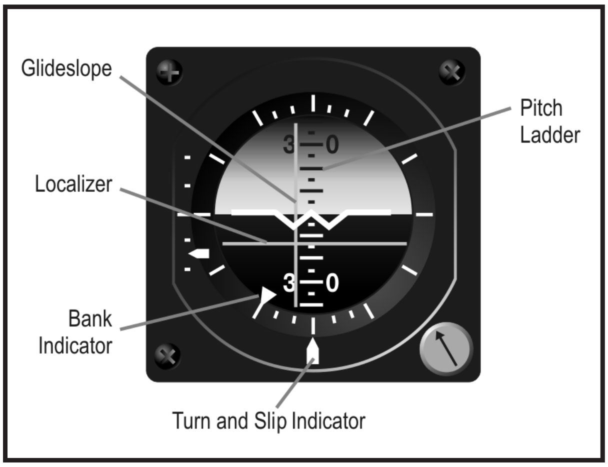
## 2.106 Accelerometer

The accelerometer displays instantaneous positive and negative acceleration G-loads. Markers highlight the maximum positive and negative G-loads achieved. The instrument is independent of, and less accurate than, the G-load displayed on the HUD.




Accelerometer

## 2.107 Attitude Director Indicator (ADI)

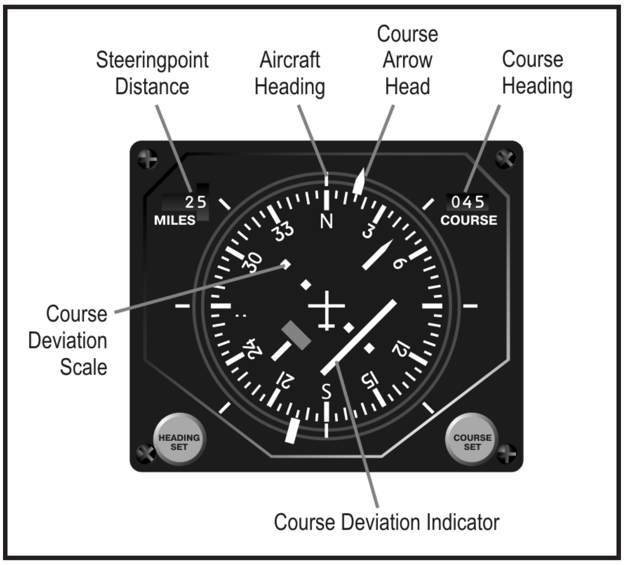



Longitudinal Aiming Mode Symbology

The Attitude Director Indicator (ADI) dominates the center of the instrument panel. The rolling attitude sphere displays the aircraft's pitch and bank angles. Pitch markings are graduated in 5-degree increments. The bank markings are graduated in 10-degree increments. During Instrument Landing System (ILS) approaches, the ILS bank steering (localizer) and glideslope bars appear in front of the attitude sphere. During ILS landings, fly toward the ILS needles.

The turn-and-slip indicator resides at the bottom of the instrument. When not centered, apply rudder toward the needle to center the indicator.

## 2.108 Horizontal Situation Indicator (HSI)




The HSI

The Horizontal Situation Indicator (HSI) shows a horizontal, top-down view of the aircraft superimposed on a compass. The compass rotates so that the aircraft heading always appears at the top of the display. The outer edge of the compass ring shows the course arrow, indicating the direction of the next navigation point.

The course deviation indicator in the center of the compass illustrates the intended course relative to the aircraft in the center of the instrument. During an ILS landing, the bar corresponds with the bank steering bar, showing deviation from the localizer beam. Please note, however, that the course deviation indicator moves the opposite direction of the ILS bank steering bar.

The desired heading is also displayed numerically on the right side of the instrument. The distance to the destination, in nautical miles, is shown on the left side of the instrument.


The Altimeter

## 2.109 Altimeter

The altimeter displays altitude above sea level (MSL) in 20-foot increments. It consists of a numeric readout in the center with a clock-like display along the outside edge, which graphically displays the "hundreds" of feet. In the example shown, the numeric readout shows an altitude of 29,093 feet. The needle, therefore, points to 93.


## 2.110 Vertical Velocity Indicator (VVI)

The Vertical Velocity Indicator (VVI) indicates the aircraft's rate of climb (or descent) in thousands of feet per minute. The needle counts clockwise from zero as the aircraft climbs, and counts counter-clockwise as the aircraft descends.

The Vertical Velocity Indicator


## 2.111 Engine Tachometer

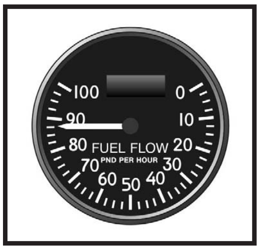
This pair of instruments indicates the engine speed as a percentage of maximum RPM for both the left and right engines. The red band indicates afterburner.

Engine Tachometers


## 2.112 Fan Turbine Inlet Temperature (FTIT) Indicators

Located below the tachometers, this pair of instruments combines an analog pointer and digital readout. The temperature is shown in increments of 10 degrees centigrade. The red band indicates excessive temperature.

FTIT Indicators




## 2.113 Fuel Flow Indicators

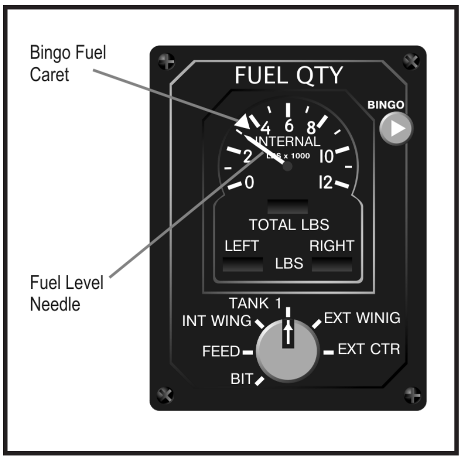
This pair of instruments shows the fuel flow, including afterburner, for each engine. Flow is measured in pounds per hour.

Fuel Flow Indicators


## 2.114 Exhaust Nozzle Position Indicators

Located in the lower right of the instrument panel, this pair of instruments shows the exhaust nozzle position for each engine. The display shows the position as a percentage of being completely open.

Exhaust Nozzle Position Indicators

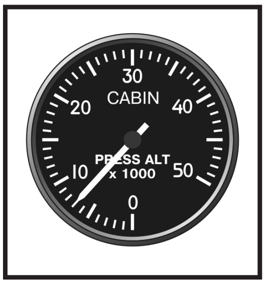



## 2.115 Fuel Quantity Indicator

The fuel quantity indicator shows the remaining fuel in the internal and external tanks. The needle in the center of the display shows the internal fuel, measured in thousands of pounds. Three numeric indicators show the total fuel remaining (internal and external), the fuel remaining in the left wing tank, and the fuel remaining in the right wing tank. All three displays measure the remaining fuel in pounds.

Fuel Quantity Indicator

### 2.116 Cabin Pressure Indicator

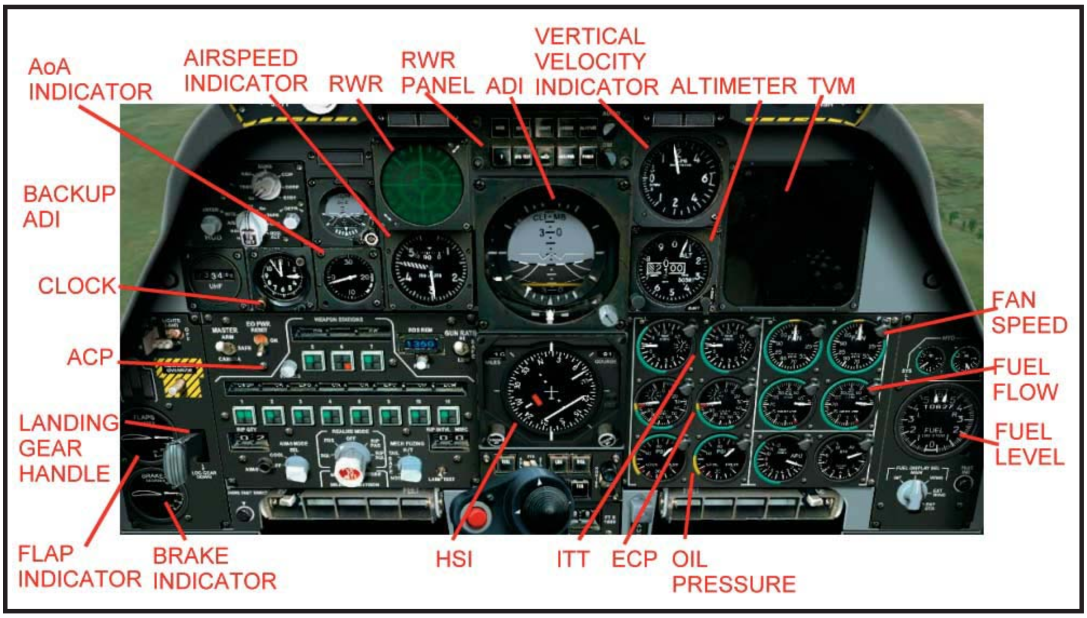


Cabin Pressure Indicator

The cabin pressure indicator shows the current "altitude" inside the cockpit based on the air pressure in the cabin. In the event of structural damage, the cabin may lose air pressure, causing the cabin altitude to increase. If the cabin pressure altitude climbs above 10,000 feet, descend immediately!

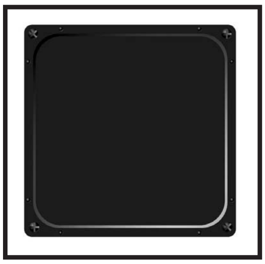
## 2.2. A-10A Cockpit

Designed specifically for Close Air Support (CAS) ground attacks, the A-10A doesn't carry radar or many of the advanced electronic systems found in other fighters. It has a much simpler cockpit dominated by navigational and engine instruments. The sole TV screen shows only images from AGM-65 Maverick seekers.



The A-10A Cockpit

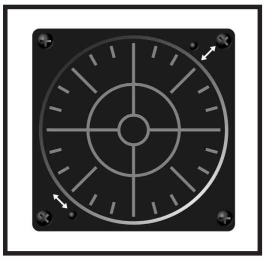
### 2.201 TV Monitor



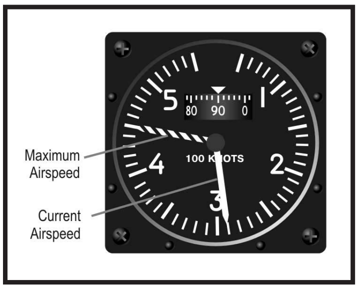
The TV Monitor (TVM) displays the view from the AGM-65 Maverick missile-seeker head. A description of AGM-65 displays and the targeting process is included in the "Sensors" chapter.

The TV Monitor

### 2.202 Radar Warning Receiver (RWR)


The RWR

The A-10's radar warning system consists of two instruments. The Radar Warning Receiver (RWR), located in the right side of the instrument panel, listens for radar emissions (from other aircraft, surface-to-air missile launchers, etc.). It categorizes the information it "hears," displaying clues about the direction and source of the emitter. The RWR control indicator, located just below the HUD, provides additional details about the sources of radar emissions. Full usage and symbology details appear in the RWR chapter.




Airspeed / Mach Indicator

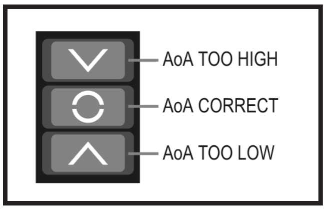
## 2.203 Airspeed Indicator

Located just below the RWR scope, the airspeed indicator shows Calibrated Airspeed (CAS) from 50 to 500 knots, and reads within 4 knots of the airspeed displayed on the HUD. The striped needle moves to show the limiting structural airspeed.


AOA Indicator

## 2.204 AOA Indicator

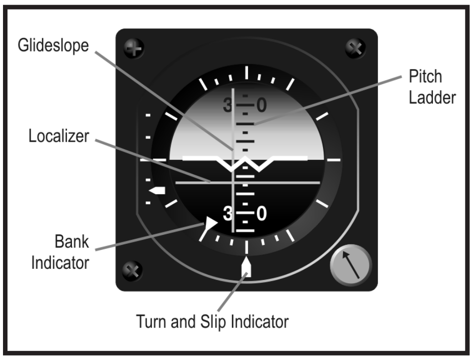
Located to the left of the Airspeed Indicator, the AOA indicator displays the current Angle Of Attack in units from zero to 30. The units are calibrated against the A-10A's normal flight envelope – a single unit does not equate to a single degree of pitch. An index mark is set at the approximate optimum landing approach AOA (20 units).




AOA Indexer

## 2.205 AOA Indexer

The AOA indexer sits on the canopy railing just left of the HUD. It displays three indicators comparing the current AOA with the proper landing approach AOA. When the top light illuminates, the AOA is either too high or the airspeed is too slow. When the bottom light illuminates, the AOA is either too low or the airspeed is too high. When the center light illuminates, the aircraft is maintaining the correct landing AOA. Slight errors are indicated when the center light illuminates in conjunction with one other light.



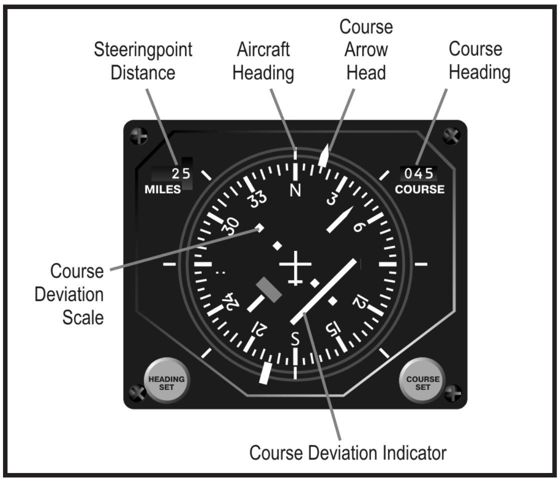

The ADI

## 2.206 Attitude Director Indicator (ADI)

The Attitude Director Indicator (ADI) dominates the center of the instrument panel. The rolling attitude sphere displays the aircraft's pitch and bank angles. Pitch markings are graduated in 5-degree increments. The bank markings are graduated in 10-degree increments. During Instrument Landing System (ILS) approaches, the ILS bank steering (localizer) and glideslope bars appear in front of the attitude sphere. During ILS landings, fly toward the ILS needles.

The turn-and-slip indicator resides at the bottom of the instrument. When not centered, apply rudder toward the needle to center the indicator.

## 2.207 Horizontal Situation Indicator (HSI)




HSI

The Horizontal Situation Indicator (HSI) shows a horizontal, top-down view of the aircraft superimposed on a compass. The compass rotates so that the aircraft heading always appears at the top of the display. The outer edge of the compass ring shows the course arrow, indicating the direction of the next navigation point.

The course deviation indicator in the center of the compass illustrates the intended course relative to the aircraft in the center of the instrument. During an ILS landing, the bar corresponds with the bank steering bar, showing deviation from the localizer beam. Please note, however, that the course deviation indicator moves the opposite direction of the ILS bank steering bar.

The desired heading is also displayed numerically on the right side of the instrument. The distance to the destination, in nautical miles, is shown on the left side of the instrument.


## 2.208 Altimeter

The altimeter displays altitude above sea level (MSL) in 20-foot increments. It consists of a numeric readout in the center with a clock-like display along the outside edge, which graphically displays the "hundreds" of feet.

The Altimeter


## 2.209 Vertical Velocity Indicator (VVI)

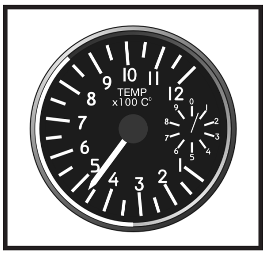
The Vertical Velocity Indicator (VVI) indicates the aircraft's rate of climb (or descent) in thousands of feet per minute. The needle counts clockwise from zero as the aircraft climbs, and counts counter-clockwise as the aircraft descends.

The Vertical Velocity Indicator


## 2.210 Accelerometer

The accelerometer displays instantaneous positive and negative acceleration G-loads. Markers highlight the maximum positive and negative G-loads achieved.

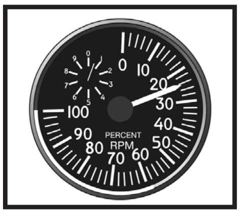
Accelerometer




## 2.211 Interstage Turbine Temperature (ITT) Indicators

This pair of instruments displays the temperature between the high and low-pressure turbine sections in degrees C.

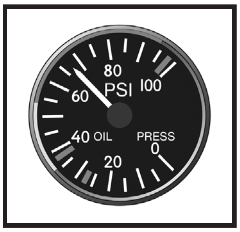
Interstage Turbine Temperature Indicators



Engine Core Speed Indicator

## 2.212 Engine Core Speed Indicator

This pair of instruments indicates the compressor core speed as a percentage of maximum RPM for both the left and right engines.



Engine Oil Pressure

## 2.213 Engine Oil Pressure Indicator

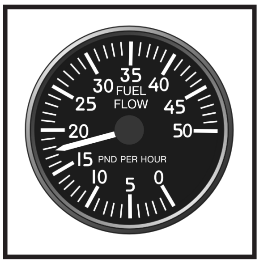
This pair of instruments indicates the engine oil pressure reading in psi. If pressure drops below 27.5 psi, the engine oil pressure caution light illuminates.

Fan Speed Indicator

## 2.214 Fan Speed Indicator

This pair of instruments indicates the engine speed as a percentage of maximum RPM for both the left and right engines. Engine fan speed is the primary indicator of thrust being generated by the A-10A's TF-34 engines.

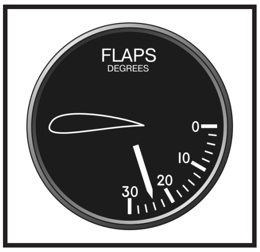
**► Engine fan speed provides the best indication of thrust being generated in the A-10A.**




## 2.215 Fuel Flow Indicators

This pair of instruments shows the fuel flow for each engine. Flow is measured in pounds per hour.

Fuel Flow Indicators




## 2.216 Flaps Indicator

The flaps indicator shows the position of the flaps.

Flaps Indicator

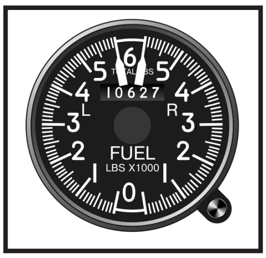

## 2.217 Brake Indicator

The brake indicator shows the position of the speed brake.

Brake Indicator

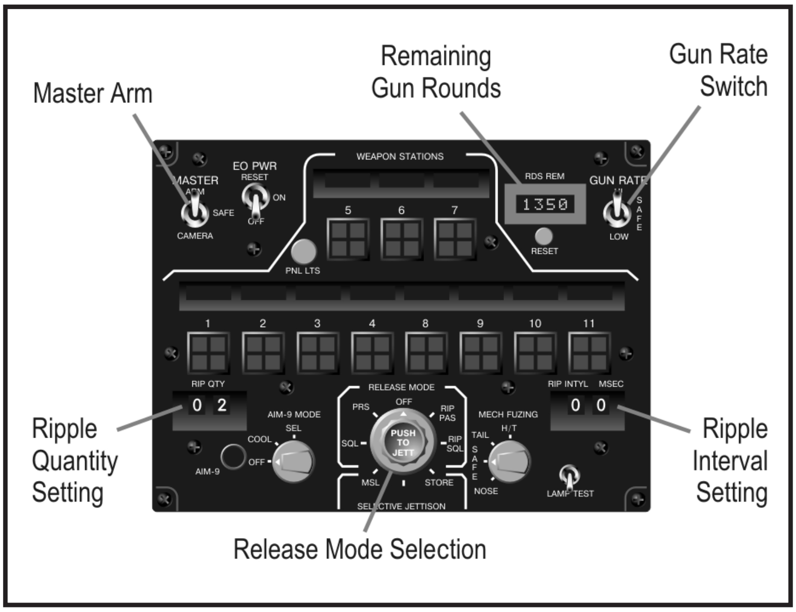
## 2.218 Fuel Quantity Indicator

The fuel quantity indicator shows the remaining fuel in the internal and external tanks. The digital readout shows internal fuel remaining. The left and right pointers indicate fuel remaining in the left and right tanks, respectively.



Fuel quantity indicator

## 2.219 Armament Control Panel




Armament Control Panel

The armament control panel dominates the lower left side of the instrument panel, showing the quantity and status of each of the A-10A's eleven hardpoints. Each hardpoint is represented by a square of four lights.

The two upper lights in each square represent the quantity of weapons (or jamming pods) on that hardpoint. If both upper green lights are lit, there are two or more weapons on that hardpoint. If only one upper green light is lit, there is only one weapon on that hardpoint. When all weapons on the hardpoint are exhausted, the upper lights turn off and the red light on the bottom row illuminates.

The green light in the lower row indicates the "active" or selected hardpoint. Cycling through available weapons causes the green light in the lower row to move from hardpoint to hardpoint.

## 2.220 Ripple Quantity Indicator

**▶Automatically releasing multiple bombs with a single press of the release button is called "rippling."**

The Ripple Quantity indicator shows the number of bombs that will be released per drop.

## 2.221 Ripple Interval

The Ripple Interval indicator indicates the spacing in milliseconds times ten between each bomb release. For example, "50" would equate to 500 milliseconds, or 0.5 seconds.

## 2.222 Cannon Rate Switch

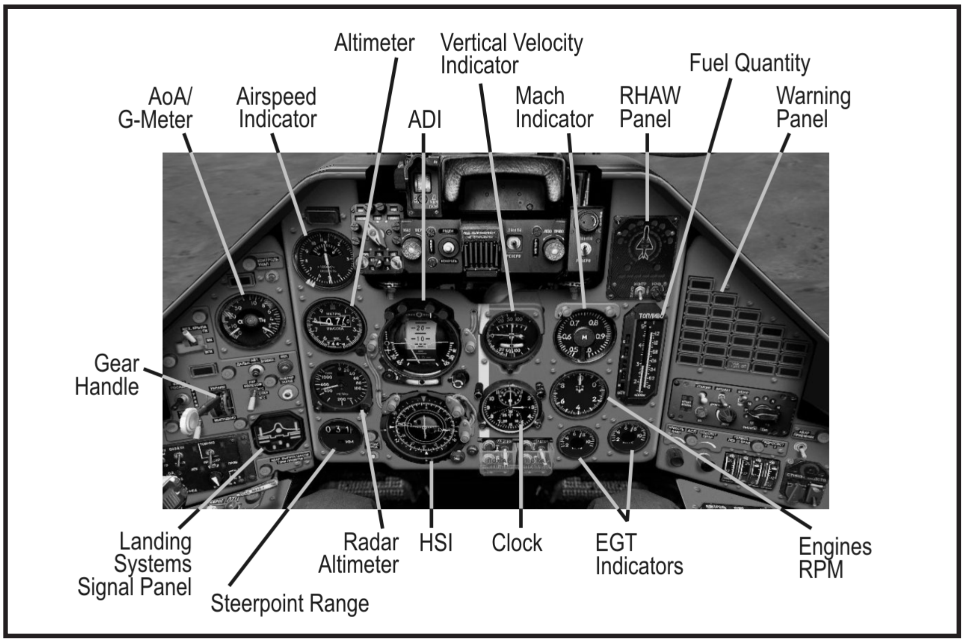
The Cannon Rate switch selects between the high (60 rounds per second) and low (30 rounds per second) rates of fire for the 30mm cannon.

## 2.223 Master Arm Switch

The Master Arm switch enables ARM and disables SAFE in the weapons system. The switch should be in the SAFE position during takeoff, landing, and flying over friendly territory. Switch to ARM to enable the weapons when entering hostile airspace.

## 2.3. Su-25 FrogFoot Cockpit

The Su-25 cockpit is relatively simple, dominated by a series of analog gauges. In addition, most instruments are the same as (or very similar to) Su-27 and MiG-29 cockpits.

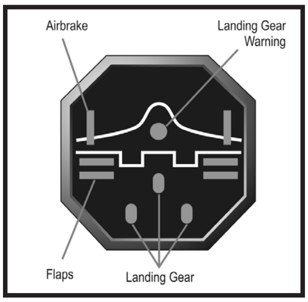



The Su-25 Cockpit


### 2.301 Indicated Airspeed (IAS) Indicator

The IAS indicator shows the aircraft's indicated airspeed (IAS). The scale ranges from 0 to 800 km/h.

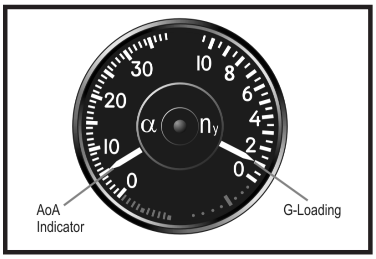
IAS Indicator




Landing System Signal Panel

### 2.302 Landing System Signal Panel

The landing system signal panel shows the deployment status of the landing gear, flaps, Leading Edge Flaps (LEF), and speed brakes. The red light in the center illuminates when any of the landing gear is not locked in the position of the landing gear handle (up or down). The light flashes if one or more landing gear is locked up but the handle is down, or if the LEF are down but the handle is up.




### 2.303 Combined AOA/G-Meter

The combined AOA/G-meter simultaneously displays the aircraft's angle of attack and current g-load. The pointer on the left shows the current AOA in degrees. The long needle on the right side of the instrument shows the current g-load.

Combined AOA/G-Meter

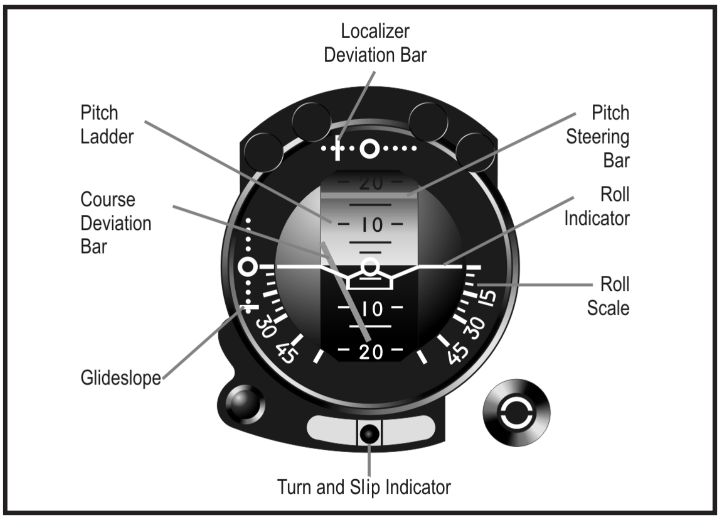
### 2.304 Attitude Director Indicator (ADI)

The ADI simultaneously shows current flight attitude and course guidance information. The numeric tape in the center shows the aircraft's current pitch and bank angle. The horizontal lines remain parallel with the horizon at all times. The turn-and-slip indicator at the bottom indicates the current sideslip. As always, apply rudder toward the sliding ball (also called "stepping on the ball") to center it.

**▶"Step on the ball" in the turn-and-slip indicator (apply rudder toward it) to center it and correct sideslip.**

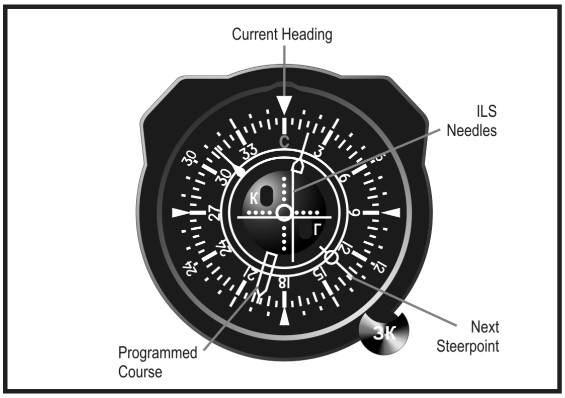
The horizontal Pitch Steering Bar in the center of the instrument indicates the correct pitch angle to reach the next waypoint. Likewise, the Course Steering Bar leans left or right, indicating the correct course to the next waypoint. When both bars are centered, the aircraft is on course.

During landings, the W-shaped glideslope deviation indicator and course deviation indicator provide Instrument Landing System (ILS) direction. If either channel of the ILS system has failed, the appropriate OFF light illuminates. During automatic landing approaches, the appearance of either light indicates an automatic level-off by the flight control system.




ADI

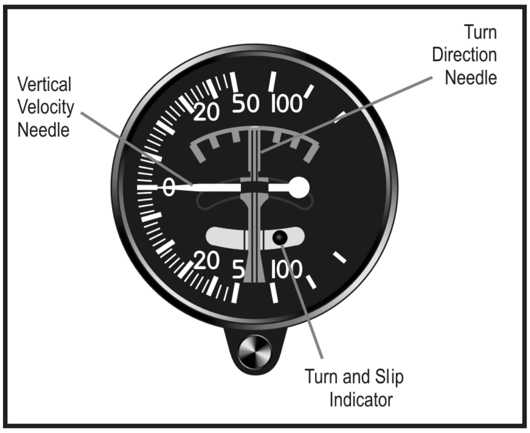
## 2.305 Horizontal Situation Indicator (HSI)




HSI

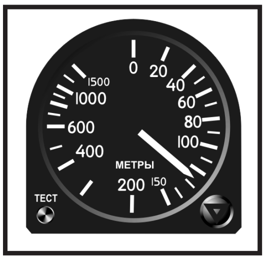
The Horizontal Situation Indicator (HSI) provides a horizontal view of the aircraft with respect to the navigation course. The compass card rotates such that the correct heading is always displayed at the very top. The course pointer shows the desired heading, while the bearing pointer points directly toward the next waypoint. The range counter indicates the distance in kilometers to the next steer point while the bearing counter provides a numeric readout of the desired heading. ILS localizer and glideslope bars are located within the center of the compass.

## 2.306 Vertical Velocity Indicator (VVI)




VVI

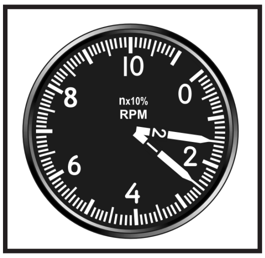
The needle moves along the left edge of the Vertical Velocity Indicator (VVI), indicating the aircraft's current rate of climb or descent. A turn-and-slip indicator in the center provides backup should the ADI malfunction. The turn needle in the center leans toward the direction of the turn, but does not provide accurate rate-of-turn information.




## 2.307 Radar Altimeter

The radar altimeter shows the aircraft's current Altitude above Ground Level (AGL), from 0 to 1,000 meters. It does not indicate altitude when above 1,000 meters.

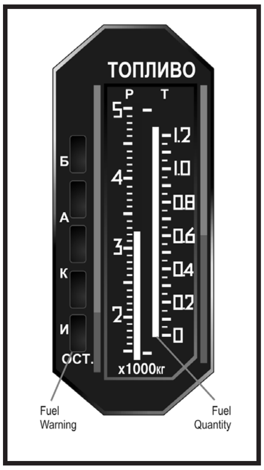
Radar Altimeter




## 2.308 Engine RPM Indicator

The engine RPM indicator shows the current speed of both engines as a percentage of maximum RPM.

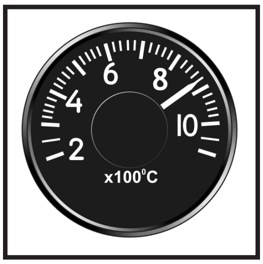
Engine RPM Indicator




## 2.309 Fuel Quantity Indicator

The fuel quantity indicator shows the amount of fuel remaining onboard, from 0 to 10 tons. The white tape shows the total fuel quantity.

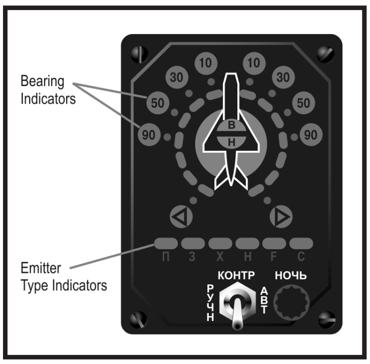
Fuel Quantity Indicator




## 2.310 EGT Indicators

The Exhaust Gas Temperature (EGT) indicators show the exhaust temperature from 200 degrees C to 1,000 degrees C.

EGT




## 2.311 Radar Homing And Warning (RHAW) Display Panel

The Radar Homing And Warning (RHAW) panel indicates the direction and source of detected radar emitters. The Aircraft symbol represents your position; the lights around it indicate the bearing to the emitter. The six lights along the bottom indicate the radar type. See the "Radar Warning Receivers" chapter for additional details.

RHAW Display Panel

## *Weapons Display 2.312*

In the rightmost side of the weapons console, there are two small windows displaying cyrillic letters. These letters identify the type of weapons available in the currently selected pylons:

- **HPC: Rockets**
- **YP: Missiles (either AG or AA)**
- **B: Bombs**
- **BPY: Cannon**
- **Black and white stripes: no cannon rounds left**

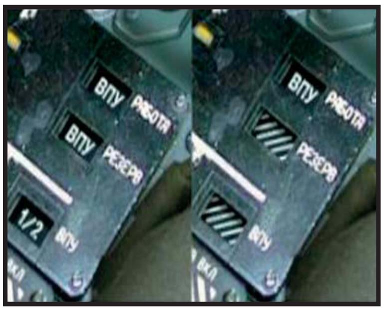
Pylons #2 & #9 selected and ready (green lights). Weapon of choice: rockets (HPC). Below "HPC" it reads "BPY" meaning the cannon is operational.

Pylons #3 & #8 selected. #3 is not green because it is carrying an ECM pod, not a weapon. Pylon 8 carries a missile (YP).

Pylons #4 & #7 selected. Weapon of choice: missiles (YP). As you can see, we are moving inwards through the pylons.

Pylons #5 and #6 selected. #6 is not green because it is carrying a fuel tank. 5 carries a bomb (b).

Selecting the cannon as the active weapon is indicated by the label (BPY). In the bottom window there is a "K" meaning we have between 1/2 and a full load of ammo rounds.



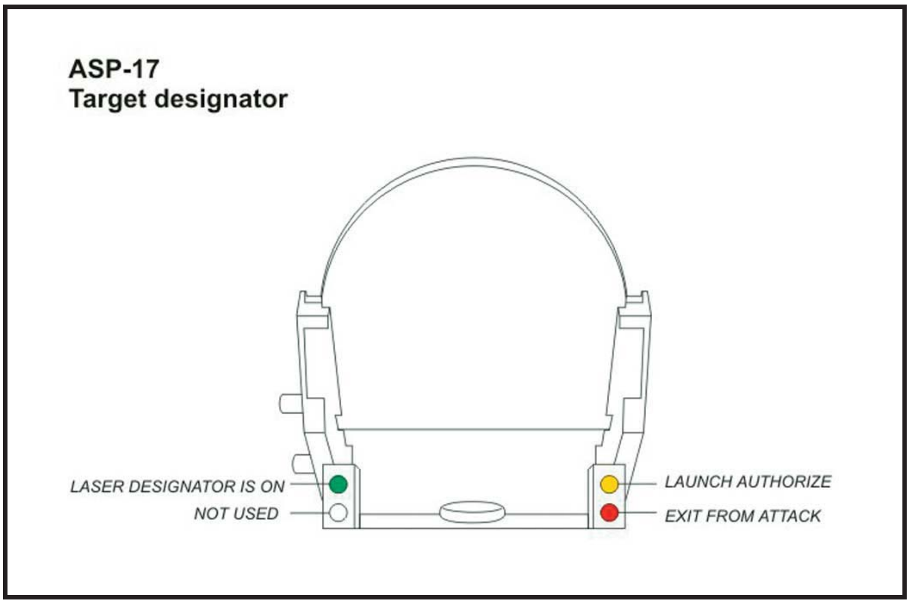
As we fire the cannon, available rounds will eventually get below 1/2. This is shown by the label "1/2". If we keep firing, the next label will be "1/4". When no more rounds are left there will appear a black and white striped label.

## 2.313 ECM Light


Before engaging hostile forces it is a good idea to switch on our ECM pod. A green light will appear on the right console to inform us that we are emitting jamming noise.

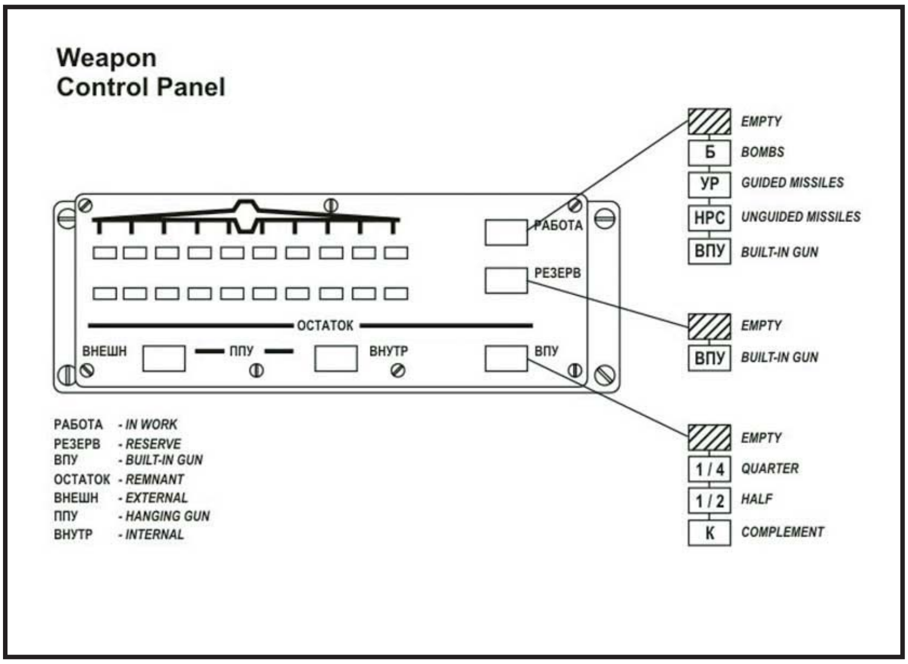
## 2.314 Heads-Up Display (HUD)

On the base of the HUD, colored lights indicate sensor and weapon status.

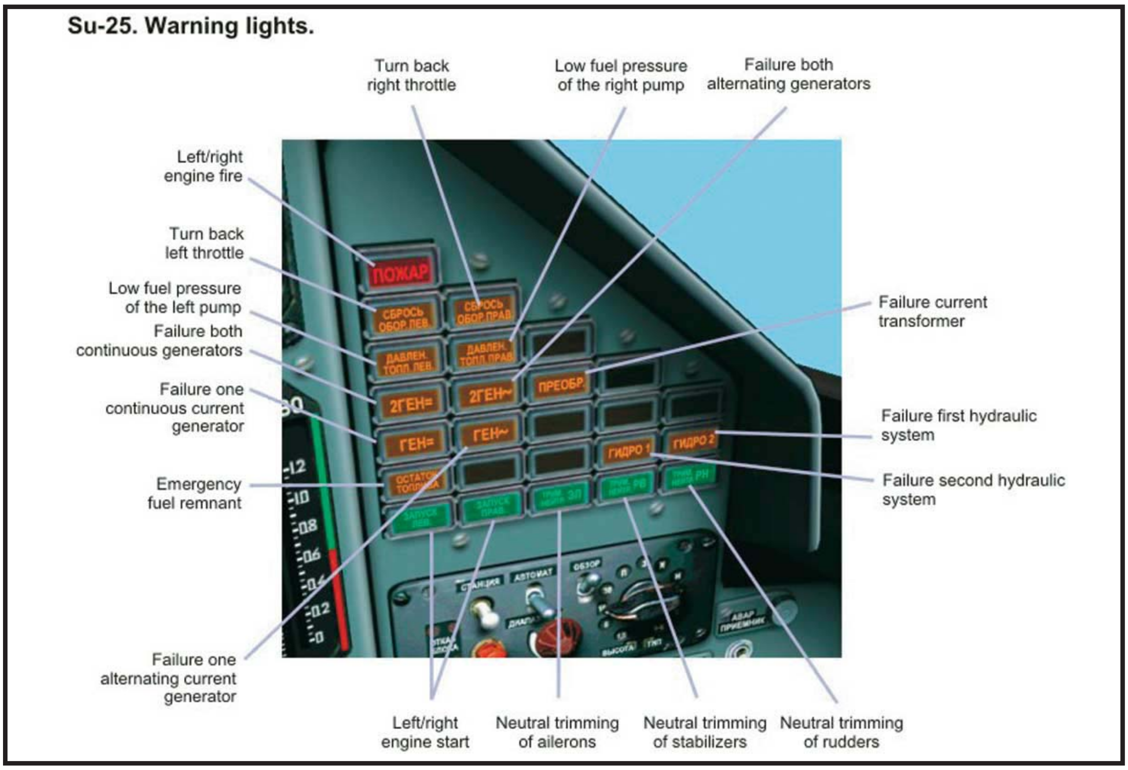



## 2.315 Weapons Panel

The weapons panel provides indications to inform the pilot of weapon status and type selected.



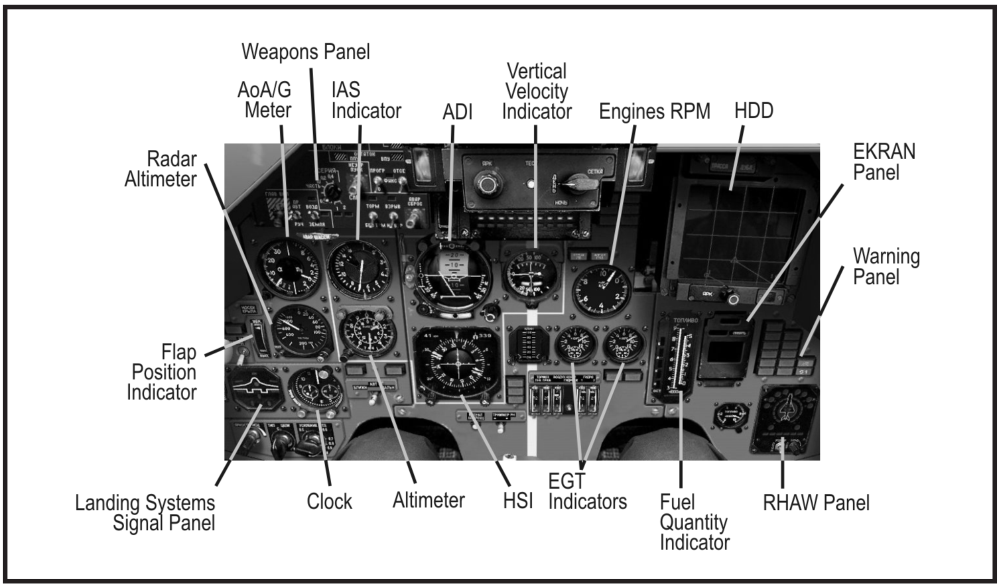
## 2.316 Warning Panel




This series of lights indicates aircraft damage and system indicators.

# 2.4. Su-27 and Su-33 Flanker Cockpit

The Su-27 and Su-33 cockpits are extremely similar. Although some control panels differ, the instrumentation is identical between the two aircraft. Furthermore, most instruments are identical (or very similar) to the MiG-29 and Su-25 cockpits.

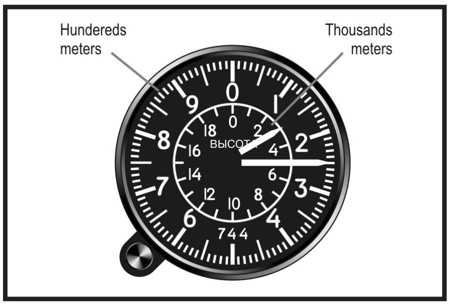



The Su-27cockpit

## 2.401 Indicated Airspeed (IAS) Indicator

IAS Indicator

The IAS indicator shows the aircraft's Indicated Airspeed (IAS). The scale ranges from 0 to 1,600 km/h.

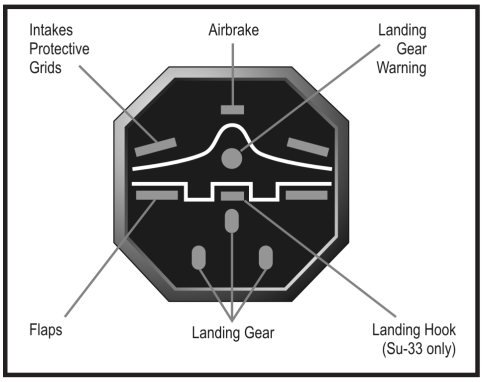



Altimeter

## 2.402 Altimeter

The altimeter shows the aircraft's altitude above sea level (MSL), from 0 to 25,000 meters. The inner ring and short needle show the altitude in thousands of meters. The outer ring and long needle show it in hundreds of feet. Add the two readings to obtain the exact altitude.

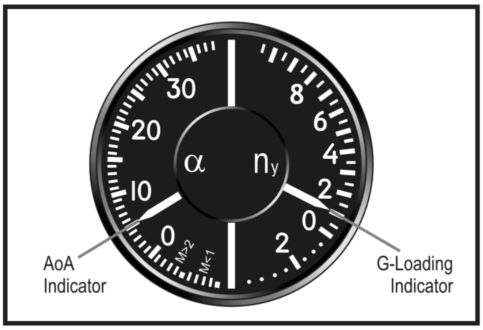
## 2.403 Landing System Signal Panel




Landing System Signal Panel

The landing system signal panel shows the deployment status of the landing gear, flaps, Leading Edge Flaps (LEF), and speed brakes. The red light in the center illuminates when any of the landing gear is not locked in the position of the landing gear handle (up or down). The light flashes if one or more landing gear is locked up but the handle is down, or if the LEF are down but the handle is up.

## 2.404 Combined AOA/G-Meter




Combined AOA/G-Meter

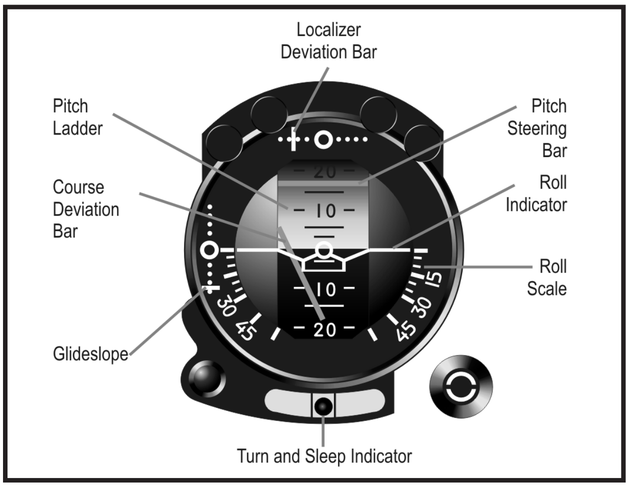
The combined AOA/G-meter simultaneously displays the aircraft's angle of attack and current G-load. The pointer on the left shows the current AOA in degrees. The long needle on the right side of the instrument shows the current G-load. The small needle indicates the maximum G-load encountered during the flight.

## 2.405 Attitude Director Indicator (ADI)

The ADI simultaneously shows current flight attitude and course guidance information. The numeric tape in the center shows the aircraft's current pitch and bank angle. The horizontal lines remain parallel with the horizon at all times. The turn-and-slip indicator at the bottom indicates the current sideslip. As always, apply rudder toward the sliding ball (also called "stepping on the ball") to center it.

**▶ "Step on the ball" in the turn-and-slip indicator (apply rudder toward it) to center it and correct sideslip.**

The horizontal Pitch Steering Bar in the center of the instrument indicates the correct pitch angle to reach the next waypoint. Likewise, the Course Steering Bar leans left or right, indicating the correct course to the next waypoint. When both bars are centered, the aircraft is on course.

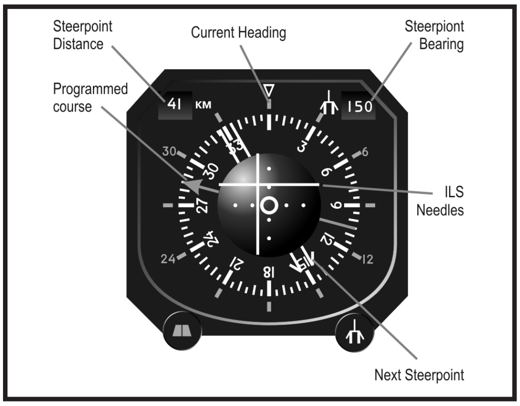



During landings, the W-shaped glideslope deviation indicator and course deviation indicator provide Instrument Landing System (ILS) direction. If either channel of the ILS system has failed, the appropriate OFF light illuminates. During automatic landing approaches, the appearance of either light indicates an automatic level-off by the flight control system.

ADI

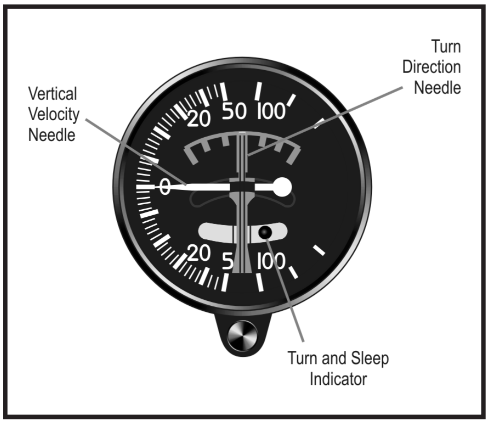
## 2.406 Horizontal Situation Indicator (HSI)

The Horizontal Situation Indicator (HSI) provides a horizontal view of the aircraft with respect to the navigation course. The compass card rotates such that the correct heading is always displayed at the very top. The course pointer shows the desired heading, while the bearing pointer points directly toward the next waypoint. The range counter indicates the distance in kilometers to the next steer point, while the bearing counter provides a numeric readout of the desired heading. ILS localizer and glideslope bars are located within the center of the compass.




HSI

## 2.407 Vertical Velocity Indicator (VVI)



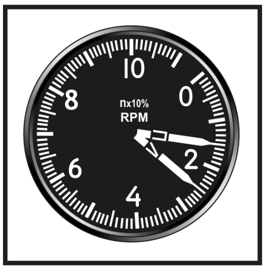

The needle moves along the left edge of the Vertical Velocity Indicator (VVI), indicating the aircraft's current rate of climb or descent. A turn-and-slip indicator in the center provides backup should the ADI malfunction. The turn needle in the center leans toward the direction of the turn, but does not provide accurate rate-of-turn information.

VVI

## 2.408 Clock

The clock shows the current time of day.

Clock



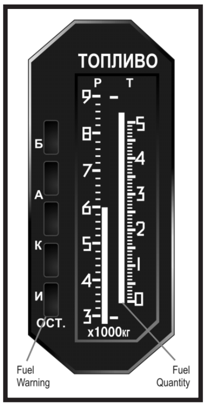

## 2.409 Engine RPM Indicator

The engine RPM indicator shows the current speed of both engines as a percentage of maximum RPM. The green lights under the indicator illuminate when the afterburner engages.

Engine RPM Indicator

## 2.410 Fuel Quantity Indicator

The fuel quantity indicator shows the amount of fuel remaining onboard, from 0 to 9 tons. The tape in the middle shows the total fuel quantity.




Fuel Quantity Indicator


## 2.411 EGT Indicators

The Exhaust Gas Temperature (EGT) indicators show the exhaust temperature from 200° C to 1,000° C.

EGT

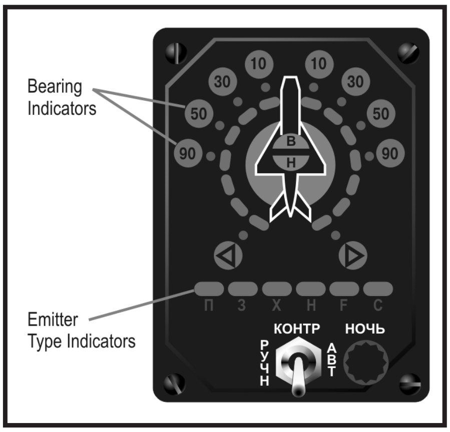

## 2.412 HDD

The Heads-Down Display (HDD) TV monitor fills the upper right corner of the instrument panel. The HDD displays the programmed flight path and steer points, the location of runways, and the location of targets detected by the radar. See the “Sensors” chapter for details on HDD usage.

HDD

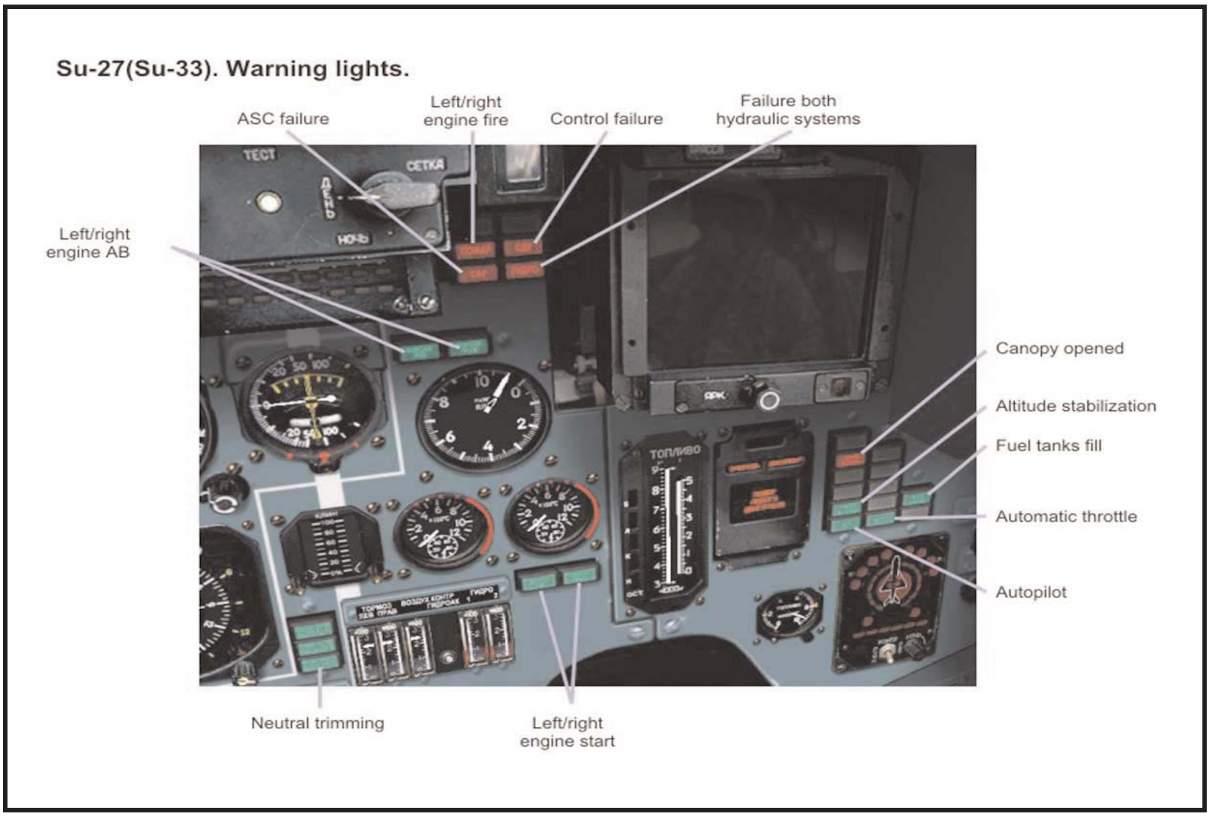
## 2.413 Radar Homing And Warning (RHAW) Display Panel

The Radar Homing And Warning (RHAW) panel indicates the direction and source of detected radar emitters. The Aircraft symbol represents your position; the lights around it indicate the bearing to the emitter. The six lights along the bottom indicate the radar type. See the "Radar Warning Receivers" Chapter for additional details.




RHAW Display Panel

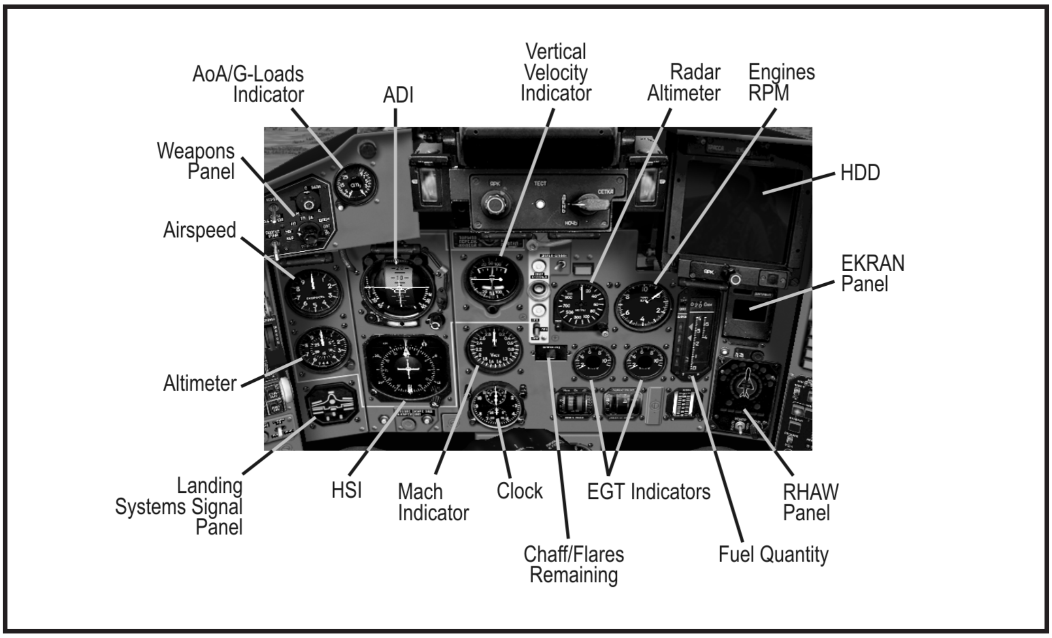
### 2.414 Warning Panel




This series of lights indicates aircraft damage and system indicators.

## 2.5. MiG-29 Fulcrum Cockpit

The MiG-29 cockpit is relatively simple, dominated by a series of analog gauges. The MiG-29A Fulcrum (used by NATO) and MiG-29S Fulcrum C cockpits are identical. In addition, most instruments are the same as (or very similar to) to Su-27 and Su-25 cockpits.

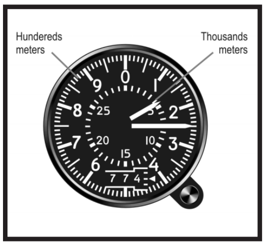



The MiG-29A and MiG-29S Cockpit


## 2.501 Indicated Airspeed (IAS) Indicator

The IAS indicator shows the aircraft's Indicated Airspeed (IAS). The scale ranges from 0 to 800 kts.

IAS Indicator



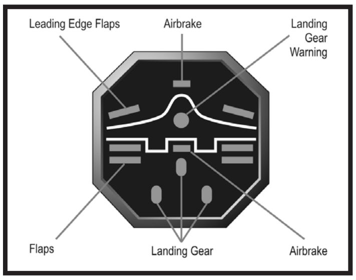

Altimeter

## 2.502 Altimeter

The altimeter shows the aircraft's altitude above sea level (MSL), from 0 to 25,000 meters. The inner ring and short needle show the altitude in thousands of meters. The outer ring and long needle show it in hundreds of feet. Add the two readings to obtain the exact altitude.

## 2.503 Landing System Signal Panel

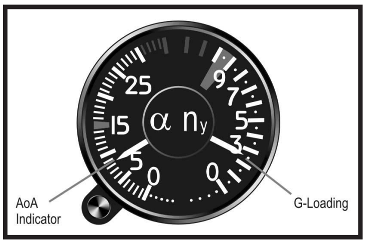
The landing system signal panel shows the deployment status of the landing gear, flaps, Leading Edge Flaps (LEF), and speed brakes. The red light in the center illuminates when any of the landing gear is not locked in the position of the landing gear handle (up or down). The light flashes if one or more landing gear is locked up but the handle is down, or if the LEF are down but the handle is up.




Landing System Signal Panel

## 2.504 Combined AOA/G-Meter

The combined AOA/G-meter simultaneously displays the aircraft's angle of attack and current g-load. The pointer on the left shows the current AOA in degrees. The long needle on the right side of the instrument shows the current g-load. The small needle indicates the maximum g-load encountered during the flight.



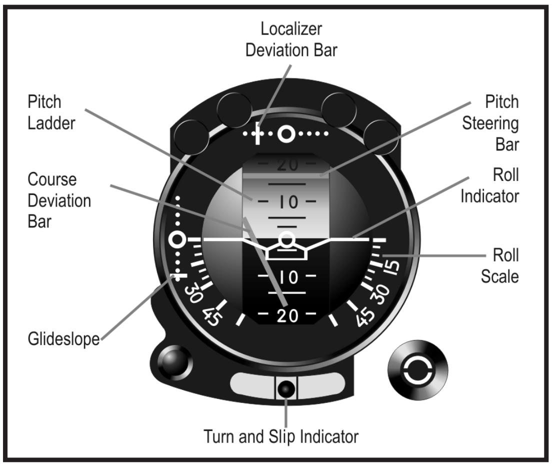

Combined AOA/G-Meter

## 2.505 Attitude Director Indicator (ADI)

The ADI simultaneously shows current flight attitude and course guidance information. The numeric tape in the center shows the aircraft's current pitch and bank angle. The horizontal lines remain parallel with the horizon at all times. The turn-and-slip indicator at the bottom indicates the current sideslip. As always, apply rudder toward the sliding ball (also called "stepping on the ball") to center it.

**► "Step on the ball" in the turn-and-slip indicator (apply rudder toward it) to center it and correct sideslip.**

The horizontal Pitch Steering Bar in the center of the instrument indicates the correct pitch angle to reach the next waypoint. Likewise, the Course Steering Bar leans left or right, indicating the correct course to the next waypoint. When both bars are centered, the aircraft is on course.

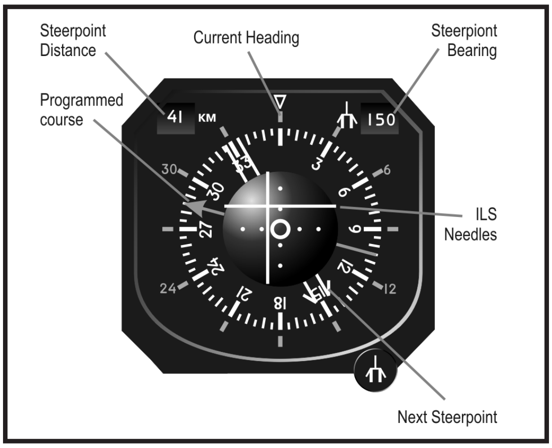


ADI

During landings, the W-shaped glideslope deviation indicator and course deviation indicator provide Instrument Landing System (ILS) direction. If either channel of the ILS system has failed, the appropriate OFF light illuminates. During automatic landing approaches, the appearance of either light indicates an automatic level-off by the flight control system.

## 2.506 Horizontal Situation Indicator (HSI)

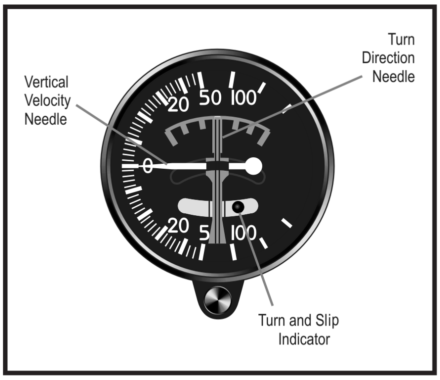
The Horizontal Situation Indicator (HSI) provides a horizontal view of the aircraft with respect to the navigation course. The compass card rotates such that the correct heading is always displayed at the very top. The course pointer shows the desired heading while the bearing pointer points directly toward the next waypoint. The range counter indicates the distance in kilometers to the next steer point, while the bearing counter provides a numeric readout of the desired heading. ILS localizer and glideslope bars are located within the center of the compass.



HSI

## 2.507 Vertical Velocity Indicator (VVI)

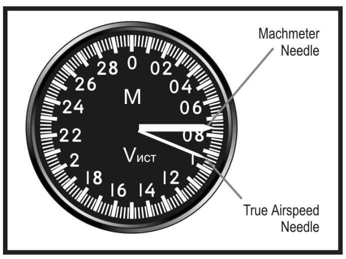
The needle moves along the left edge of the Vertical Velocity Indicator (VVI), indicating the aircraft's current rate of climb or descent. A turn-and-slip indicator in the center provides backup should the ADI malfunction. The turn needle in the center leans toward the direction of the turn, but does not provide accurate rate-of-turn information.



VVI

## 2.508 Mach Indicator

The Mach indicator shows the aircraft's current Mach number.

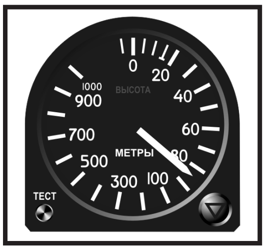


Mach Indicator

## 2.509 Clock

The clock shows the current time of day.

Clock

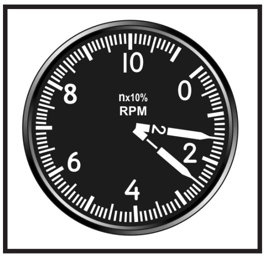



## 2.510 Radar Altimeter

The radar altimeter shows the aircraft's current Altitude above Ground Level (AGL), from 0 to 1,000 meters. It does not indicate altitude when above 1,000 meters.

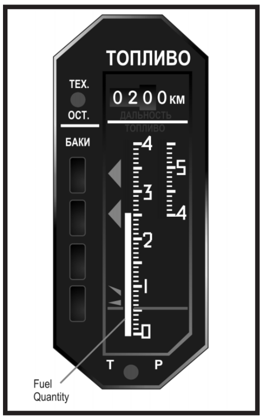
Radar Altimeter

## 2.511 Engine RPM Indicator




The engine RPM indicator shows the current speed of both engines as a percentage of maximum RPM. Green afterburner indicators at the far right of the instrument panel indicate when afterburners are engaged.

Engine RPM Indicator




## 2.512 Fuel Quantity Indicator

The fuel quantity indicator shows the amount of fuel remaining on board, from 0 to 5.5 tons. The tape in the middle shows the total fuel quantity. The four triangular indicators show the amount of fuel in the centerline (CL), wing (WING), tank 1, and tank 3. The four lights illuminate as the respective tanks are emptied.

Fuel Quantity Indicator

## 2.513 EGT Indicators

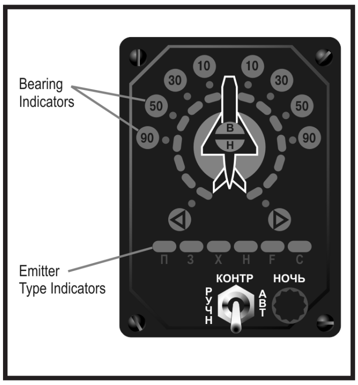
The Exhaust Gas Temperature (EGT) indicators show the exhaust temperature from 200° C to 1,000° C.

EGT


## 2.514 HDD

The Heads-Down Display (HDD) TV monitor fills the upper right corner of the instrument panel. The HDD displays the programmed flight path and steer points, the location of runways, and the location of targets detected by the radar. See the "Sensors" chapter for details on HDD usage.

HDD



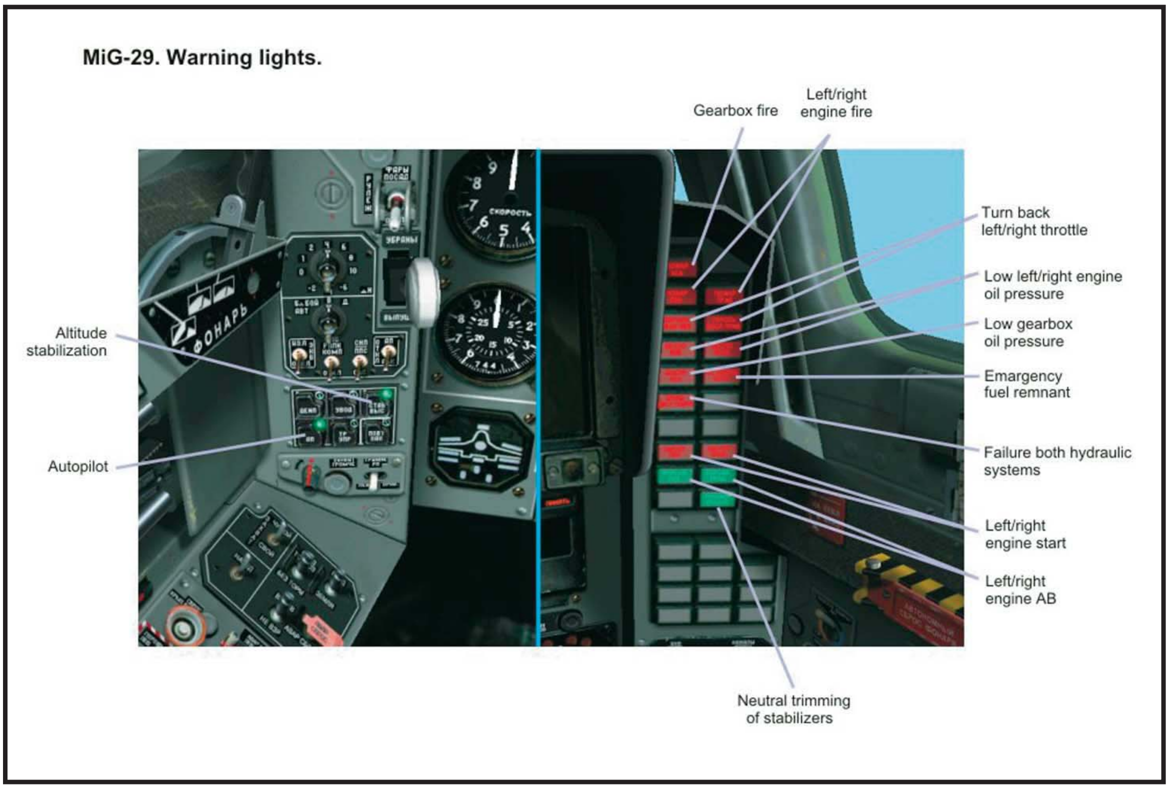

RHAW Display Panel

## 2.515 Radar Homing and Warning (RHAW) Display Panel

The Radar Homing And Warning (RHAW) panel indicates the direction and source of detected radar emitters. The Aircraft symbol represents your position; the lights around it indicate the bearing to the emitter. The six lights along the bottom indicate the radar type. See the "Radar Warning Receivers" chapter for additional details.

## 2.516 Warning Panel

This series of lights indicates aircraft damage and system indicators.

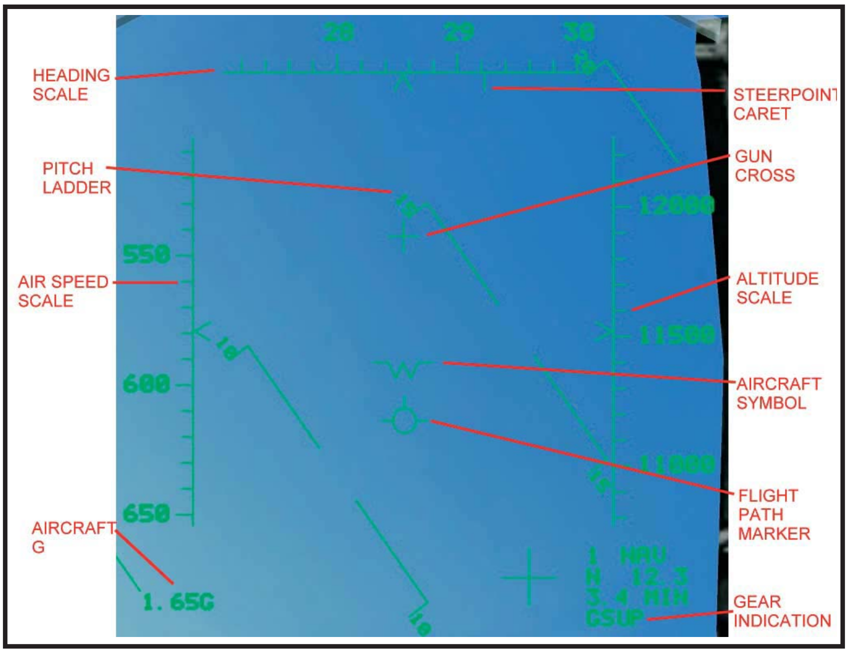


# HEADS-UP DISPLAY MODES

## 3.1. F-15C Eagle HUD Modes

### 3.101 Basic HUD Symbology

Several indicators on the F-15C HUD are common to all HUD modes.

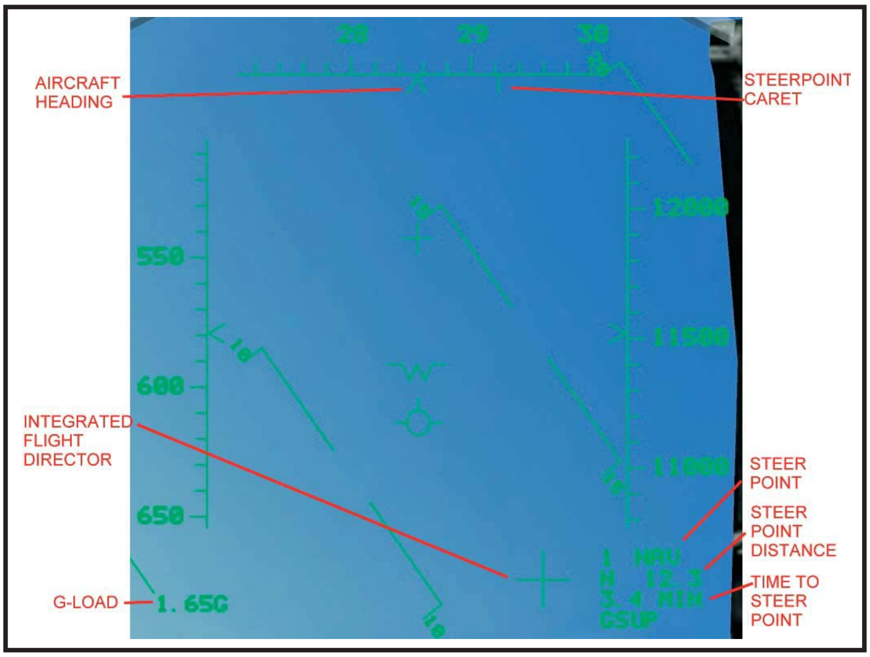



Basic HUD Symbology

- The Aircraft symbol, similar to the letter "W," appears exactly in the center of the HUD and indicates where the aircraft's nose is pointing.
- The heading scale appears along the top edge, displaying the heading rounded to the nearest ten (for example, 270 appears as 27).
- The airspeed scale on the left edge shows the Indicated Airspeed (IAS) in knots. The airspeed scale does not display values below 150 knots.
- The altitude scale on the right edge shows the aircraft's altitude above sea level (MSL) in feet.
- The velocity vector moves through the middle of the HUD, showing the direction the aircraft is actually moving, which varies from where the aircraft is heading because of momentum, sideslip, angle of attack, etc.
- The pitch scale appears in the middle of the HUD, centered on the velocity vector. Primarily, it shows the aircraft's pitch measured in five-degree increments. The entire scale moves left and right, however, mirroring the turn-and-slip indicator on the ADI. As with the turn-and-slip indicator, to stop sideslip, apply rudder toward the scale.

### 3.102 Navigation Mode

As the name implies, navigation mode provides navigation and steering cues. Basic navigation mode points the way to the next steer point within the programmed route. ILS mode, on the other hand, provides information required during landings.




Navigation HUD

## Basic Navigation

The basic navigation mode provides steering cues to the next route steer point. In addition to the basic HUD scales, navigation mode includes the following indicators:

- The mode indicator in the lower right of the HUD displays the name of the selected steer point, followed by the mode name, "NAV."
- The distance indicator beneath the mode indicator shows the distance (in nautical miles) to the next steer point.
- The time-to-go indicator, located beneath the distance indicator, shows the time to the next steer point.
- The aircraft g indicator appears in the lower-left corner of the HUD.
- The integrated flight director appears as a cross on the HUD. It points toward the next steer point, providing both pitch and bank steering cues. To fly directly to the next steer point, steer the aircraft until the flight director is centered in the HUD, directly over the Aircraft symbol.

## ILS Mode

When ILS mode is engaged, the HUD displays the following indicators in addition to the basic navigation indicators:

- The mode indicator in the lower right of the HUD displays the identifier of the selected steer point, followed by the mode name, "ILSN."
- The landing gear status indicator appears in the lower-right corner, below the time-to-go indicator. It shows either GSUP (when the landing gear is raised) or GDWN (when the gear is lowered).
- The angle-of-attack scale appears on the left side, inside of the airspeed scale. The caret on the right side of the scale shows the current AOA. The scale measures AOA in units, not degrees, which range from 0 to 45. Landings should occur at approximately 22 units of AOA.
- The ILS needles appear just above the aircraft marker, near the center of the HUD. The horizontal bar represents the desired altitude; the vertical bar

represents the desired course. As with the ILS bars in the ADI, steer toward the bars. When the ILS bars are centered, the aircraft is following the proper approach.

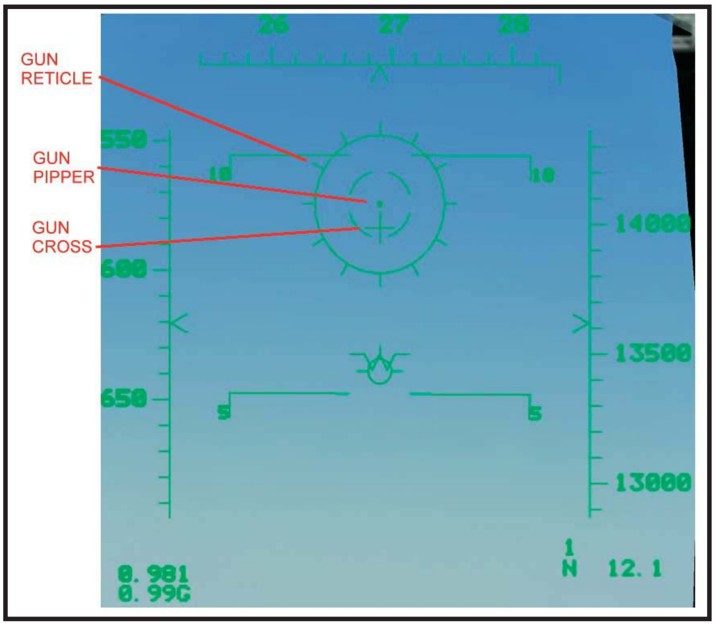
To enter ILS mode, press the 1 key to cycle between enroute navigation and ILS navigation.

## 3.103 Gun Mode Steering

The gun mode appears after enabling the internal 20mm cannon. Different indicators appear depending upon whether a target is radar locked or not. To enter gun steering mode, you first must be in air-to-air weapons mode and then activate the gun.

### Radar Search Mode

Radar search mode, also called the auto-acquisition mode, displays the basic HUD indicators plus the following additional fields:




Cannon Search Mode

- The gun reticle appears just below the heading scale. In search mode, the reticle consists of a 2-mil pipper centered inside a 25-mil segmented circle, likewise centered within a 50-mil circle. The reticle does not move and provides no information except to quickly identify that the cannon is enabled.
- Gun information appears in the lower-left corner, replacing the g indicator. The word "GUN" confirms that the gun is enabled, followed by the number and type of rounds remaining. "GUN 940 P," for example, indicates 940 rounds of PGU-38 20mm rounds.
- The Mach indicator appears beneath the gun information, showing the aircraft's current Mach number.
- The navigation distance indicator appears in the lower-right corner. It shows the letter "N" followed by the distance (in nautical miles) to the next steer point.

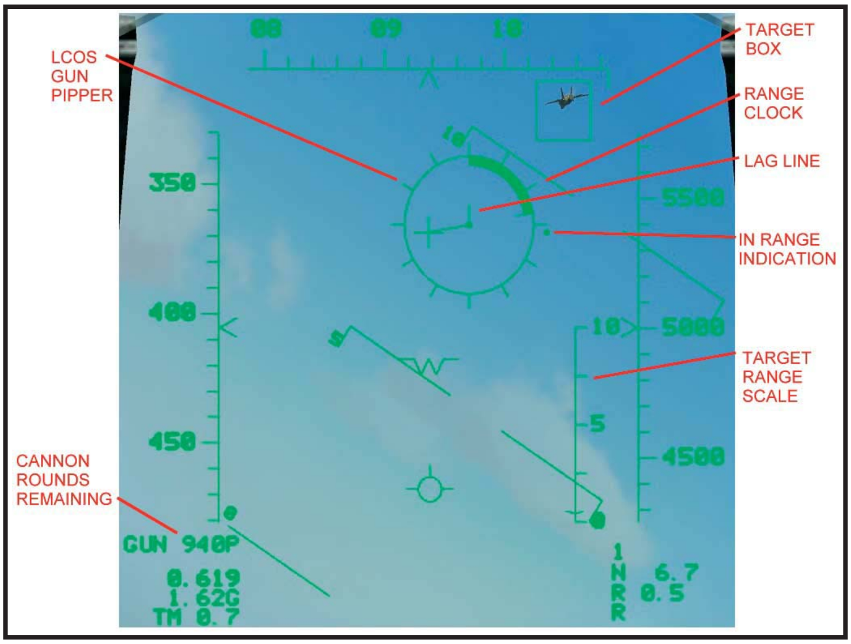
This mode is always enabled when the radar is off, or a target has not been locked on radar.

### Radar Tracking LCOS Mode

When the radar tracks a target, the HUD replaces the static reticle with the

Lead Computing Optical Sight (LCOS) and shows additional information about the target.

To initiate LCOS mode, you must first activate the radar and then lock the target by either manually locking the target on radar or flying the gun reticle over the target. Once the reticle is over the target and within 10 miles, an LCOS mode will automatically be initiated.




Cannon LCOS Mode

- The gun cross appears just below the heading scale. It shows where rounds will travel if the aircraft is not maneuvering.
- The target designator box appears over the locked target.
- The range scale appears on the right of the HUD, showing range from 0 to 10 nautical miles. The caret on the left side marks the range to the locked target. The number next the caret shows the target's closure rate. Tick marks indicate the AIM-9 minimum and maximum launch ranges (against a non-maneuvering target).
- The LCOS gun reticle shows where a round from the cannon will be when it has traveled the distance to the target and accounts for drop due to gravity. To ensure a hit, steer the aircraft until the reticle's center dot overlays the target designator box.

Additionally, the range bar within the reticle provides a graphical representation of the range to the locked target. Each tick mark on the reticle represents 1,000 feet of range, counting clockwise from the 12 o'clock position. The maximum range cue is located outside the reticle and indicates the maximum effective range of the cannon. When the range bar passes this cue moving counterclockwise, the target is within cannon range.

Finally, the lag line extends from the center of the reticle, indicating the pipper is displaying an error. The longer the lag line, the greater the probable targeting error.

- The range-to-target readout in the lower right of the HUD provides a redundant display of the range to the target, showing the letter "R" followed by the range to the locked target.
- Target aspect angle appears beneath the range-to-target readout, measuring

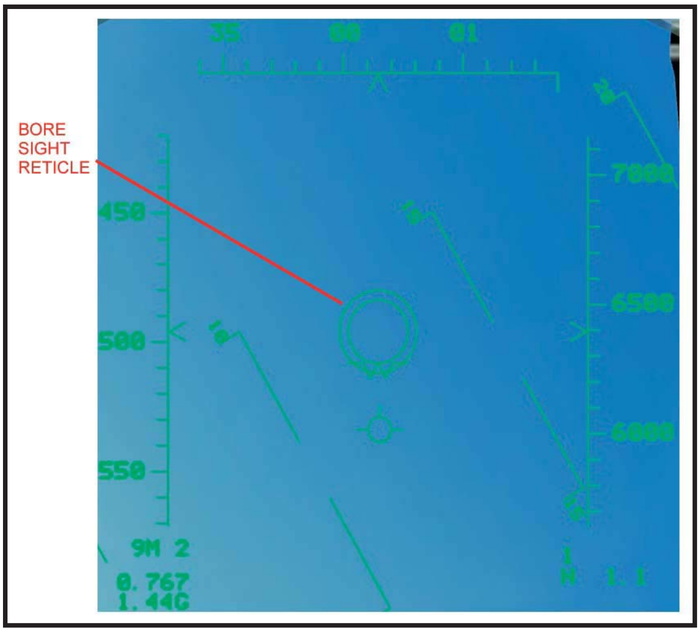
the angle between the target's tail and the line of sight to the target. The letter "R" or "L" appears after the angle, indicating which side of the target is presented toward the player's aircraft.

**▶Remember: Lower aspect angles increase the effectiveness of your weapons!**

## 3.104 AIM-9

The essential Short-Range Missile (SRM) display symbols provide weapon status and pursuit course steering. The heat-seeking AIM-9 has a seeker head completely independent from the radar. The seeker can acquire targets with or without using the radar. Once the missile is launched, it receives no further guidance from the launching aircraft.

### Search Display (Seeker Boresight)

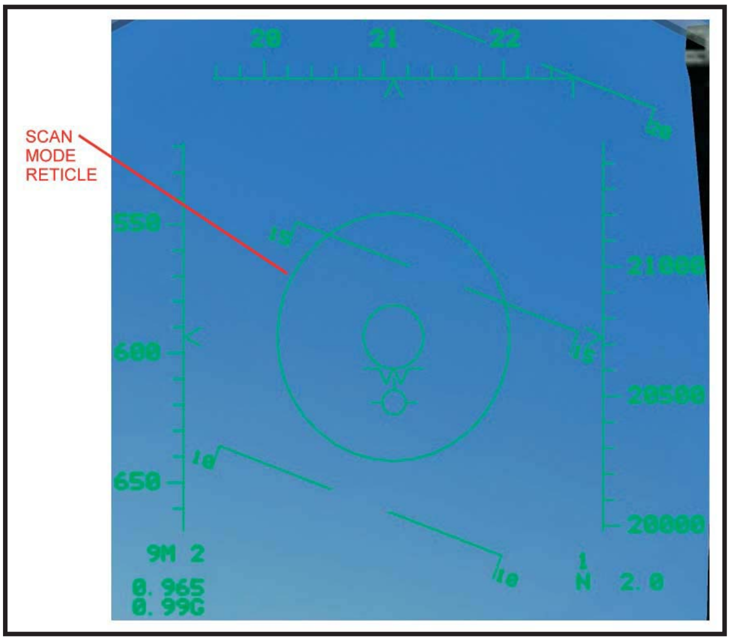



AIM-9 Boresight Mode

Selecting SRM mode with the radar in search mode, a fixed two-degree circle appears around the Aircraft symbol. This fixed circle, aligned with the missile's line of sight, represents the missile's field of view. If the target is within visual range, you may disregard radar acquisition procedures and steer the aircraft to position the target within the two-degree reference circle.

When the missile tracks the target, the SRM tone will increase in pitch. As long as the target remains within the field-of-view circle, the missile continues to track, and may be launched. If the target moves outside the field-of-view circle, the missile loses the track.

## Search Display (Seeker Uncaged)



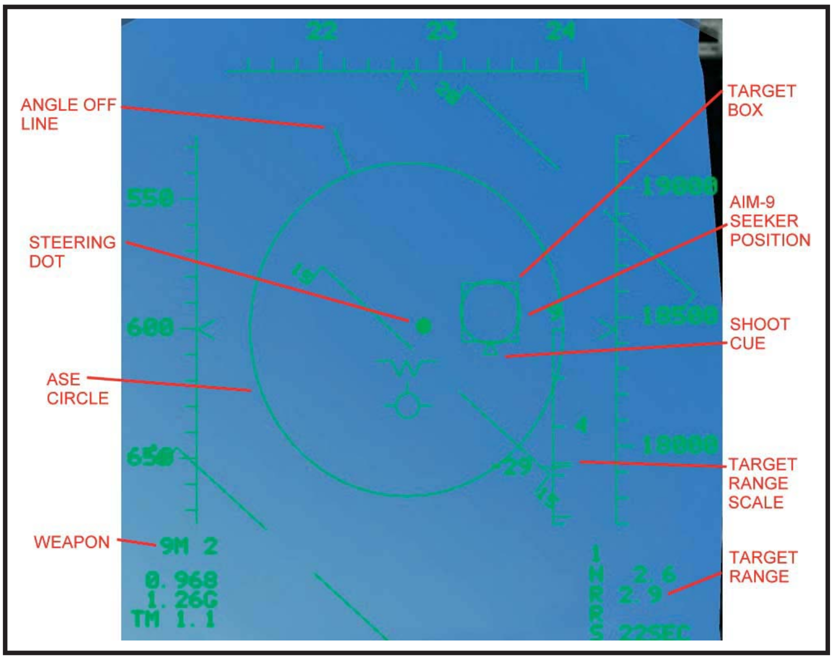

AIM-9 Seeker Uncaged

Uncaging the SRM seeker changes the HUD display. Two circles appear. The larger circle represents the missile field of view, or the entire area the seeker can move. The smaller circle represents the missile's seeker position, or where the missile is "looking" within the total field of view.

The outer, field-of-view circle always remains stationary and disappears when the missile locates a target. The inner, seeker-position circle remains fixed over the Aircraft symbol until a target is detected; then the seeker-position circle moves to follow the target. A steady, high-pitched tone indicates the seeker is locked.

## Track Display

With a radar lock established, the HUD provides substantially more information about the target. If the range to the target is greater than 12,000 feet (outside the effective AIM-9 range), the HUD provides steering cues to a launch position:




AIM-9 Target Tracking Display

- The steering dot directs the pilot where to steer the aircraft to achieve a launch position.
- The Allowable Steering Error (ASE) circle provides a frame of reference for the missile launch, representing the missile's field of view. The circle doubles in size when the missile's seeker has acquired the target. Maneuver the aircraft to place the steering dot in the center of the ASE circle.
- The angle-off line appears outside the ASE, providing a graphical

representation of the aspect angle. When the line is at the top of the circle, the target is moving directly away. When the line is at the bottom, the target is moving directly toward the aircraft.

**►Even though the AIM-9 is an all-aspect, heat-seeking weapon, it is far more effective at lower aspect angles.**

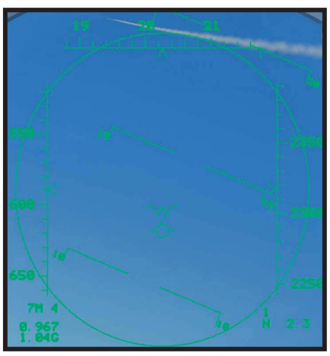
- The Target Designator (TD) box shows the target's position, tracked by the radar. Maneuver the TD box inside the ASE circle.
- The range scale appears on the right of the HUD, showing a range from 0 to 10 nautical miles. The caret on the left side marks the range to the locked target. The number next the caret shows the target's closure rate. The dark marks near the bottom of the scale indicate the missiles maximum and minimum launch range (against a non-maneuvering target). When the caret is between the marks, the target is within the missile's launch envelope.
- The data block in the lower-right corner of the HUD provides additional target information. The first line reads "R" (for radar track) followed by the range to the target (in nautical miles). The second line indicates the time it will take the missile to reach the target. The final line displays the target's aspect angle. The letter "U" appears before the aspect angle if the seeker has been uncaged (scan mode).

When the target is within 12,000 feet, additional information appears on the HUD:

- A range bar appears within the ASE circle. The range bar counts down counterclockwise, with tick marks representing the AIM-9's maximum and minimum launch ranges. A large "X" appears across the HUD when the target is closer than the missile's minimum launch range.
- A flashing, triangular "shoot" cue appears beneath the TD box, indicating conditions are favorable for a missile launch. The Master Arm switch must be enabled, the target must be within the missile's minimum and maximum launch ranges, and the steering dot must be within the ASE circle.

## 3.105 AIM-7

The AIM-7 is one of two Medium-Range Missiles (MRM) carried by the F-15. The semi-active AIM-7 requires the launching aircraft to maintain a radar lock for the entire flight of the missile. When using AIM-7 missiles, the HUD has four distinct modes.



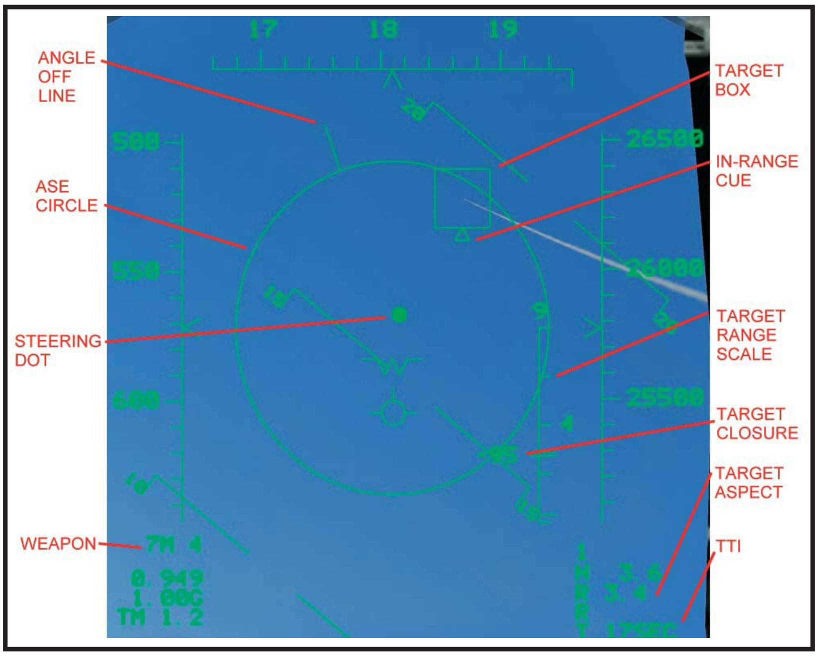
AIM-7 Relaxed Mode Display

### Relaxed Display

Relaxed mode appears when selecting AIM-7 missiles without a radar-locked target. The basic navigation HUD contains a fixed reference circle, indicating the missile's field of view. The type of missile and quantity appears in the lower-left corner, above the Mach number.

## FLOOD Mode

FLOOD mode immediately energizes a wide-area radar emission. The radar does not lock on to any targets, per se; however, AIM-7 missiles can home in on the radar reflections from targets within the flood pattern. The word "FLOOD" appears in the lower-right corner of the HUD.




AIM-7 Target Tracking Display

The reference circle expands to illustrate the flood pattern. As long as the target remains within the reference circle, the missile will track. If the target moves outside the circle, the missile loses the track and self-destructs. If multiple targets are within the scan pattern, the missile tracks the target with the greatest radar cross-section.

## Track Display

The track display appears when the radar has locked a target. The HUD provides tracking cues for the locked target:

- The Target Designator (TD) box appears over the target.
- The steering dot directs the pilot where to steer the aircraft to achieve a launch position.
- The Allowable Steering Error (ASE) circle replaces the reference circle. The ASE represents the missile's launch envelope. Steer the aircraft to bring the steering dot to the center of the ASE. In MRM mode, the ASE changes size. A smaller circle indicates greater range to the target. The ASE will flash when the radar antenna approaches the gimbal limit.
- The angle-off line appears outside the ASE, providing a graphical representation of the aspect angle. When the line is at the top of the circle, the target is moving directly away. When the line is at the bottom, the target is moving directly toward the aircraft.
- The range scale appears on the right side of the HUD. The top edge of the scale corresponds to the radar range (10, 20, 40, 80, or 160 nautical miles). Three tick marks indicate the AIM-7 minimum launch range (RMIN), the maximum launch range against a maneuvering target (RTR), and maximum launch range against a non-maneuvering target (RPI). The caret along the left side of the range scale shows the range to the target. The number next to the caret shows the target's closure rate.
- The data block in the lower-right corner of the HUD provides additional target information. The first line displays "R" (indicating a radar lock) followed by the range to the target in nautical miles. The second line displays the time it will take the next missile to reach the target. The bottom line displays the target's aspect angle.
- The data block in the lower-left corner shows the type and quantity of

missiles remaining on the top line. The aircraft's Mach number appears on the second line. After launching an AIM-7, the missile's Time-To-Intercept (TTI) counts down on the third line. After launching multiple AIM-7 missiles, the TTI for the last missile is displayed.

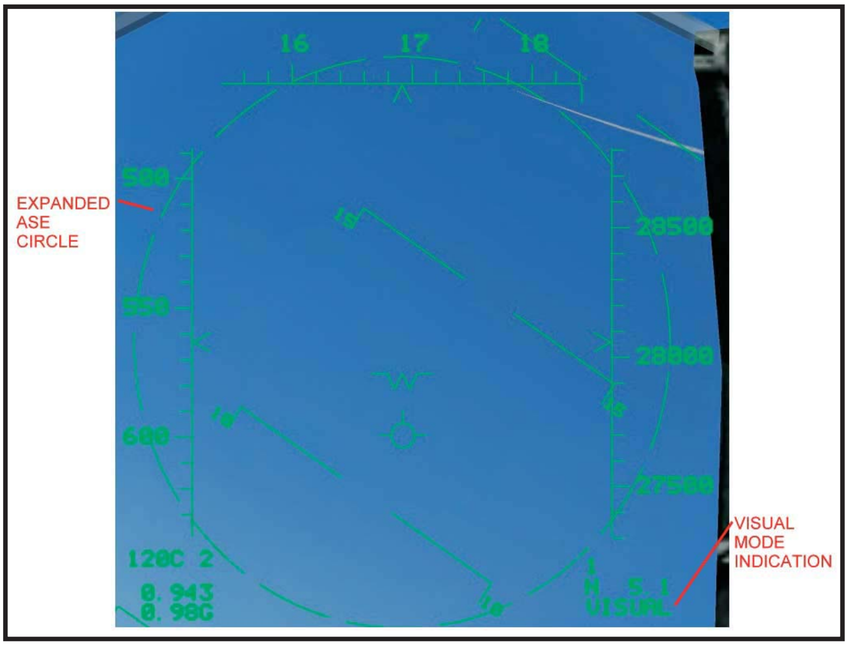
• A flashing, triangular "shoot" cue appears beneath the TD box, indicating conditions are favorable for a missile launch. The Master Arm switch must be enabled, the target must be within the missile's minimum and maximum launch ranges, and the steering dot must be within the ASE circle.

## 3.106 AIM-120

The AIM-120 is the F-15's primary Medium-Range Missile (MRM), having substantially improved performance over the AIM-7. Unlike the AIM-7, the AIM-120 has its own onboard radar. It uses control signals from the launching platform to get close to the target, and then uses its own radar for the final phase of flight.

### Visual Mode

When selecting an AIM-120 without a radar-locked target, the HUD enters visual mode. The basic navigation HUD contains a dashed reference circle. The word "VISUAL" appears in the lower-right corner of the HUD. The type and quantity of missiles appears in the lower-left corner, above the aircraft Mach number.

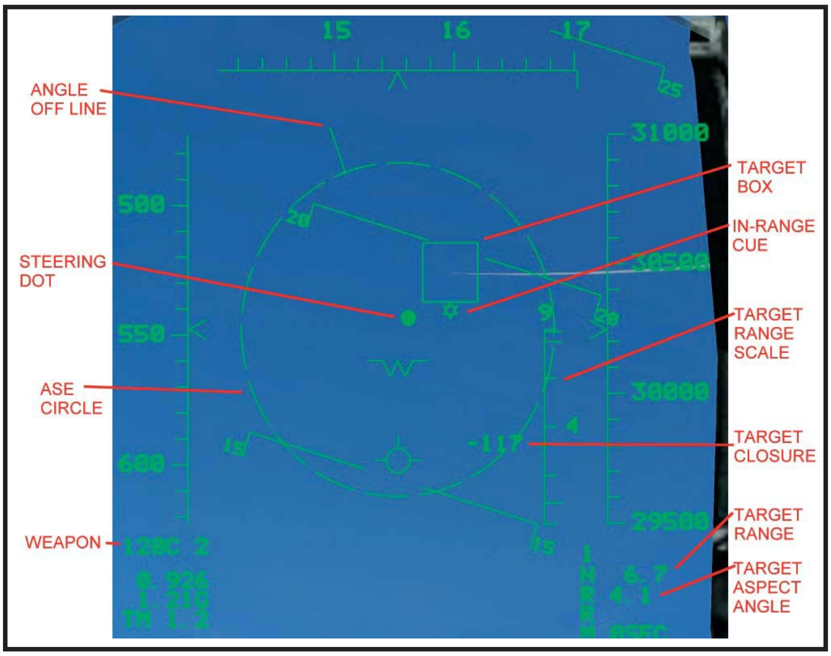



AIM-120 Visual Mode

For targets within visual range, steer the aircraft to place a target within the dashed reference circle. The missile provides no indication it has acquired a target. Two seconds after launch, its onboard radar goes active, and it will track the target with the largest radar cross-section present within the circle. The AIM-120's onboard radar can detect targets up to 15 nautical miles away. If it does not detect a target after the radar goes active, the missile will perform a series of "S" turns along its original flight path. It will engage the target with the largest radar cross-section it finds.

### Track Display

The track display appears when the radar has locked a target. The HUD displays tracking information for the locked target:




AIM-120 Target Tracking Display

- The Target Designator (TD) box appears over the target.
- The steering dot directs the pilot where to steer the aircraft to achieve a launch position.
- The Allowable Steering Error (ASE) circle replaces the reference circle. The ASE represents the missile's launch envelope. Steer the aircraft to bring the steering dot to the center of the ASE. In MRM mode, the ASE changes in size. A smaller circle indicates greater range to the target. The ASE will flash when the radar antenna approaches the gimbal limit.
- The angle-off line appears outside the ASE, providing a graphical representation of the aspect angle. When the line is at the top of the circle, the target is moving directly away. When the line is at the bottom, the target is moving directly toward the aircraft.

**▶Missiles are more effective against low-aspect angle targets.**

- The range scale appears on the right side of the HUD. The top edge of the scale corresponds to the radar range (10, 20, 40, 80, or 160 nautical miles). Three tick marks indicate the AIM-7 minimum launch range (RMIN), the maximum launch range against a maneuvering target (RTR), and maximum launch range against a non-maneuvering target (RPI). The caret along the left side of the range scale shows the range to the target. The number next to the caret shows the target's closure rate.
- The data block in the lower-right corner of the HUD provides additional target information. The first line displays "R" (indicating a radar lock) followed by the range to the target in nautical miles. The second line displays the time it will take the next missile to reach the target. The bottom line displays the target's aspect angle.
- The data block in the lower-left corner shows the type and quantity of missiles remaining on the top line. The aircraft Mach number appears on the second line. After launching an AIM-120, the missile's time-to-active (TTA) and time-to-intercept (TTI) counts down on the third line. After launching multiple AIM-120 missiles, the TTI for the last missile is displayed.

- A flashing, six-pointed "shoot" cue appears beneath the TD box, indicating conditions are favorable for a missile launch. The Master Arm switch must be enabled, the target must be within the missile's minimum and maximum launch ranges, and the steering dot must be within the ASE circle.

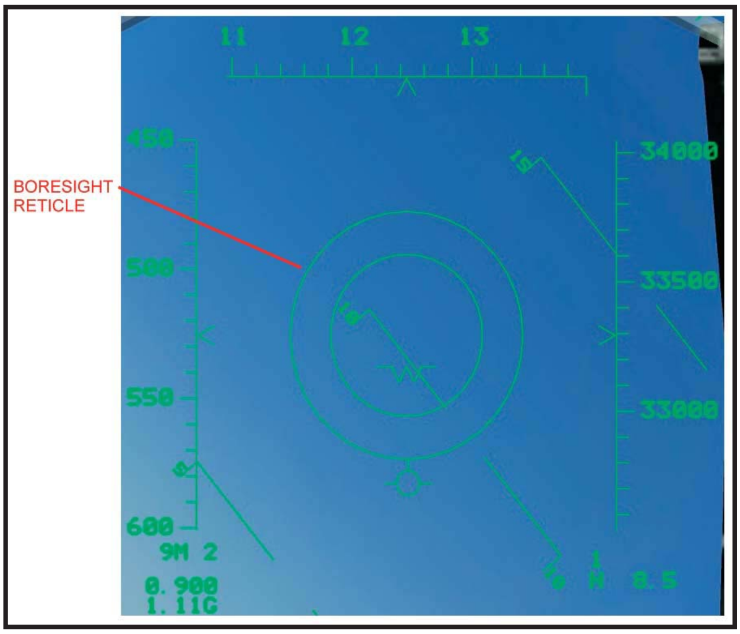
## 3.107 Auto-Acquisition Modes

The F-15's radar supports three automatic acquisition modes. Auto-acquisition modes utilize preset scan patterns to search for close-range (less than 10 nautical miles) targets. Usage instructions for auto-acquisition radar modes can be found in the "Sensors" chapter.

**▶Selecting an auto-acquisition mode with a target radar lock will break that radar lock and begin a new search.**

### Boresight (BST)

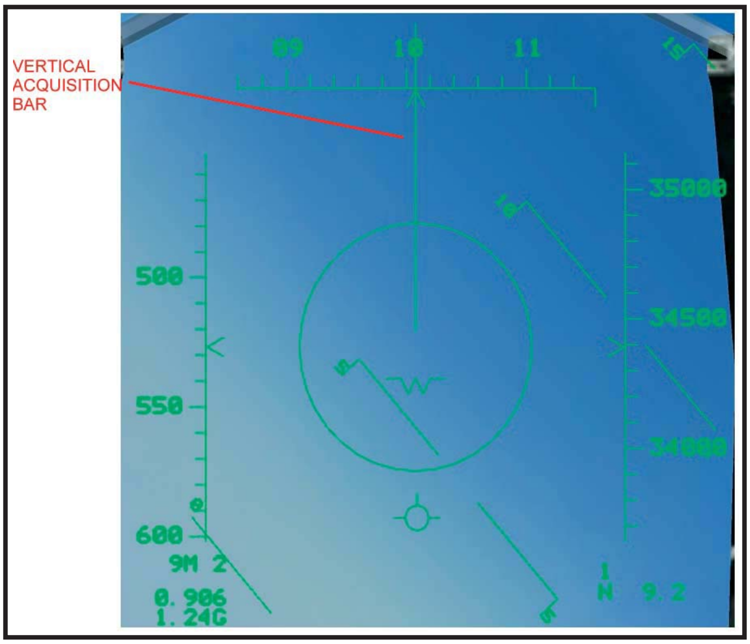
In Boresight (BST) mode, the radar searches a small area directly in front of the aircraft up to a range of 10 nautical miles. The boresight reference circle appears in the HUD, centered over the Aircraft symbol. The reference circle represents the radar's field of view in BST mode. The radar will lock the first target detected within that field of view.




Boresight Auto-Acquisition Mode

### Vertical Scan

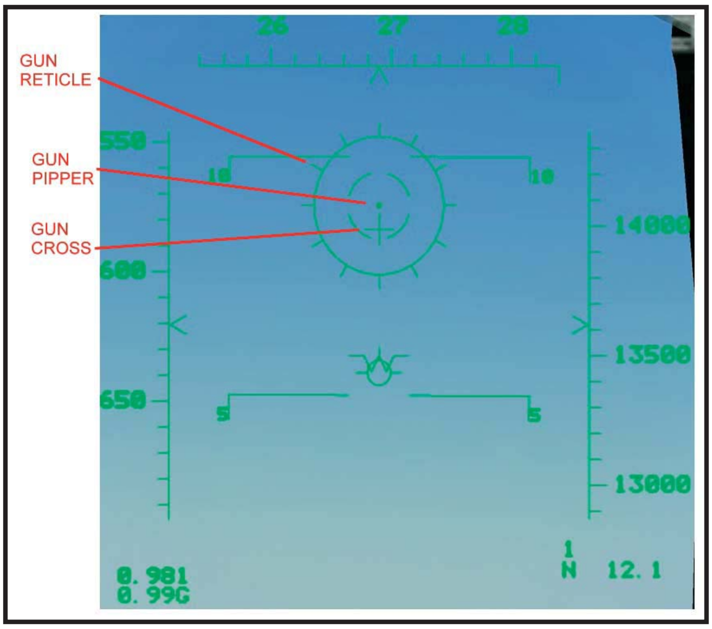
Designed for the close-range dogfight, the vertical scan mode drives the radar antenna in a tall, narrow scan pattern 7.5° wide and 50° high. In this mode, a vertical-scan reference line appears in the HUD, showing roughly where the radar is searching. The radar will lock the first target detected within 10 nautical miles.




Vertical Search Auto-Acquisition Mode

### Gun Mode

Gun mode provides a scan pattern +/- 30 degrees wide and +/- 10 degrees high. The radar will lock the first target detected within 10 nautical miles.

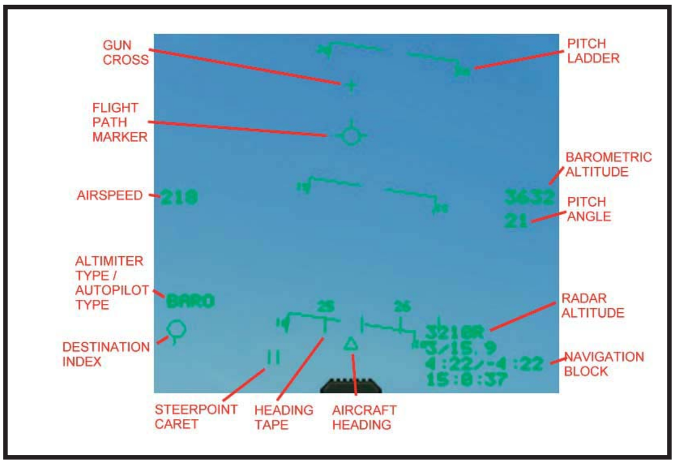



Gun Auto-Acquisition Mode

## 3.2. A-10A HUD Modes

### 3.201 Basic HUD Symbology

Several indicators on the A-10A HUD are common to all HUD modes:

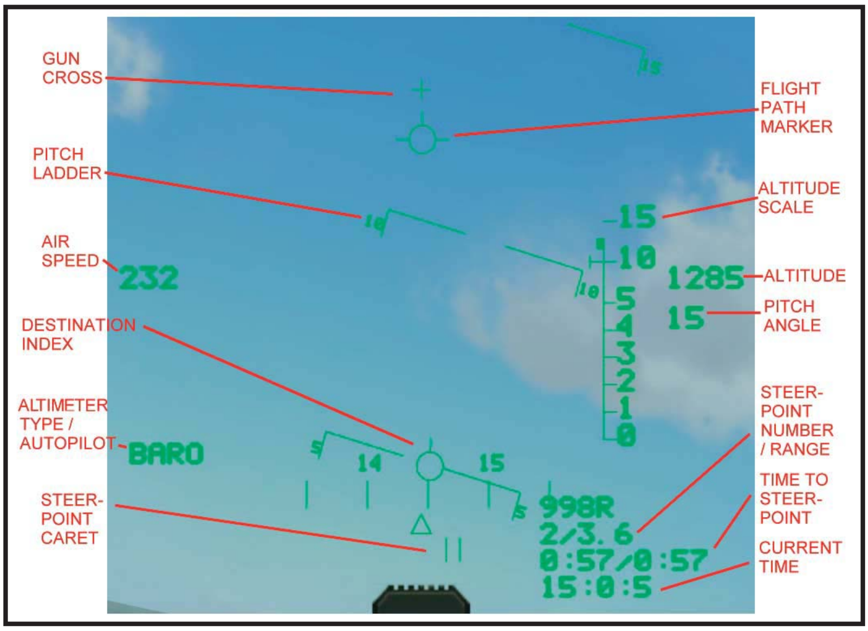



Basic A-10 HUD Symbology

- The heading scale appears along the bottom edge, displaying the heading rounded to the nearest ten (for example, 270 appears as 27).
- The digital airspeed display on the right edge shows the Indicated Airspeed (IAS) in knots.
- The digital altitude display on the right edge shows the aircraft's altitude above sea level (MSL) in feet.
- The digital pitch display appears below the altitude display on the right side of the HUD, showing the aircraft's exact pitch angle.
- The velocity vector moves through the middle of the HUD, showing the direction the aircraft is actually moving, which varies from where the aircraft is heading because of momentum, sideslip, angle of attack, etc.
- The pitch scale appears in the middle of the HUD, centered on the velocity vector. Primarily, it shows the aircraft's pitch measured in five-degree increments. The entire scale moves left and right, however, mirroring the turn-and-slip indicator on the ADI. As with the turn-and-slip indicator, to stop sideslip, apply rudder toward the scale.

## 3.202 Navigation Mode

As the name implies, navigation mode provides navigation and steering cues. Basic navigation mode points the way to the next steer point within the programmed route. ILS mode, on the other hand, provides information required during landings.




Basic Navigation Indicators

## Basic Navigation

The basic navigation mode provides steering cues to the next route steer point. In addition to the basic HUD scales, navigation mode includes the following indicators:

- The radar altitude scale appears on the right side, providing an exact, radar-determined display of the aircraft's Altitude above Ground Level (AGL). A caret moves along the scale indicating the current altitude while a digital readout (followed by the letter "R") appears in the lower-right corner of the HUD.
- Information about the next steer point is presented below the radar altitude readout. The first number indicates the ID of the next steer point. The number following the "/" indicates the distance (in nautical miles) to the next steer point.
- The time-to-go indicator, located beneath the distance indicator, shows the time to the next steer point. The number following the "/" indicates whether the aircraft will arrive early or late against the assigned time to reach that steer point. A negative number indicates a late arrival.
- The current time is displayed beneath the time-to-go indicator.
- The command heading bug indicator moves along the lower edge of the heading tape, providing a steering cue to the next steer point.
- The destination index moves within the entire HUD, pointing to the next steer point.
- The text in the lower-left corner of the HUD indicates the current autopilot mode.

| Mode | Function |
|---|---|
| PATH HLD | Path Hold |
| ALT HLD | Altitude Hold |
| BARO | No autopilot mode engaged |

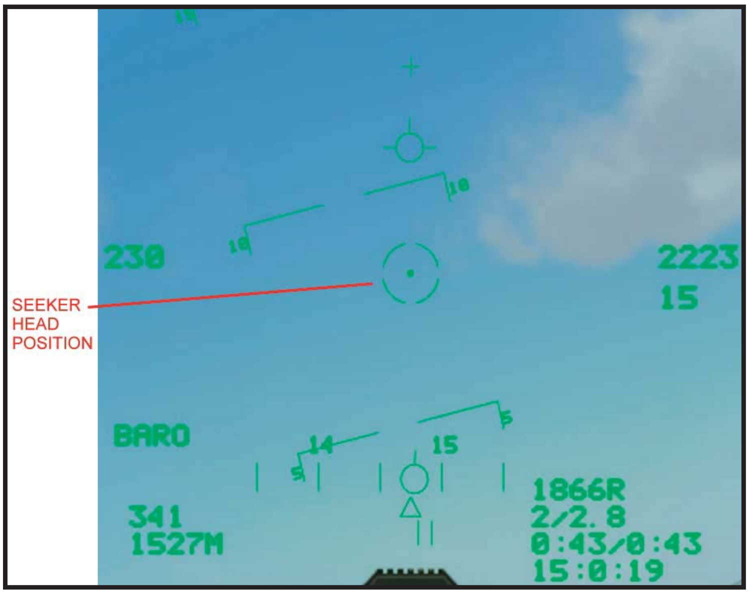
## ILS Mode

When ILS mode is engaged, the HUD displays the following indicators in addition to the basic navigation indicators:

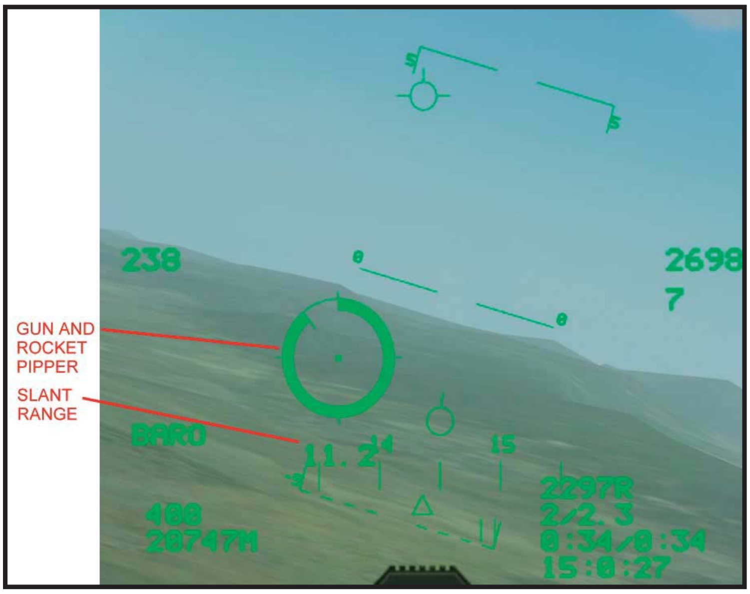
• The ILS needles appear just above the aircraft marker, near the center of the HUD. The horizontal bar represents the desired altitude; the vertical bar represents the desired course. As with the ILS bars in the ADI, steer toward the bars. When the ILS bars are centered, the aircraft is following the proper approach.

## 3.203 Gun, Rocket, and Missile Mode

The HUD displays nearly identical symbology when either the cannon, rockets, or an AIM-65 missile is selected. The radar altitude scale disappears to reduce clutter and the following additional data appears:



Typical Maverick HUD



Typical Rocket HUD

• With the cannon selected, the Continuously Computed Impact Point (CCIP) gun reticle, or "pipper," appears, showing where rounds fired right now will strike. An analog range bar counts down counterclockwise, indicating the range to the point on the ground beneath the pipper. The maximum range mark near the bottom of the pipper shows the maximum effective range of the 30mm cannon.

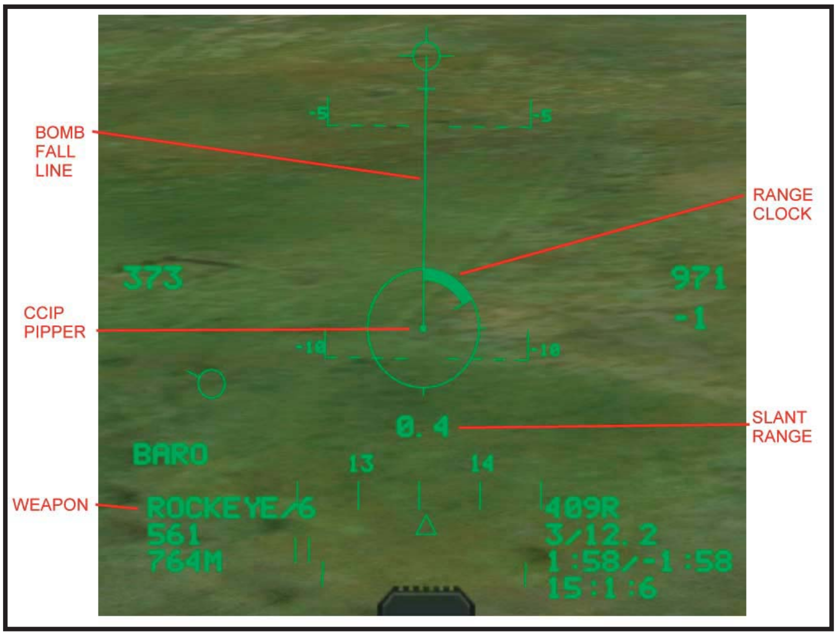
• With an AIM-65 missile selected, the Maverick symbol appears in the HUD showing where the missile seeker is looking.

• With rockets selected, the rocket pipper appears on the HUD, indicating where rockets fired right now will strike. Rockets are not extremely precise weapons, and the pipper indicates the general area where the rockets will impact.

- The selected weapon type is listed in the lower left of the HUD.
- Additional target information appears in the lower-left corner of the HUD, below the weapon type. The top number shows the elevation above sea level (MSL) of the point beneath the gun pipper or Maverick symbol. The second number shows the slant range from the aircraft to that same point.

## 3.204 Bomb Mode

Bomb mode is nearly identical to gun/missile mode, except the pipper/Maverick symbol is replaced with the CCIP bomb pipper.

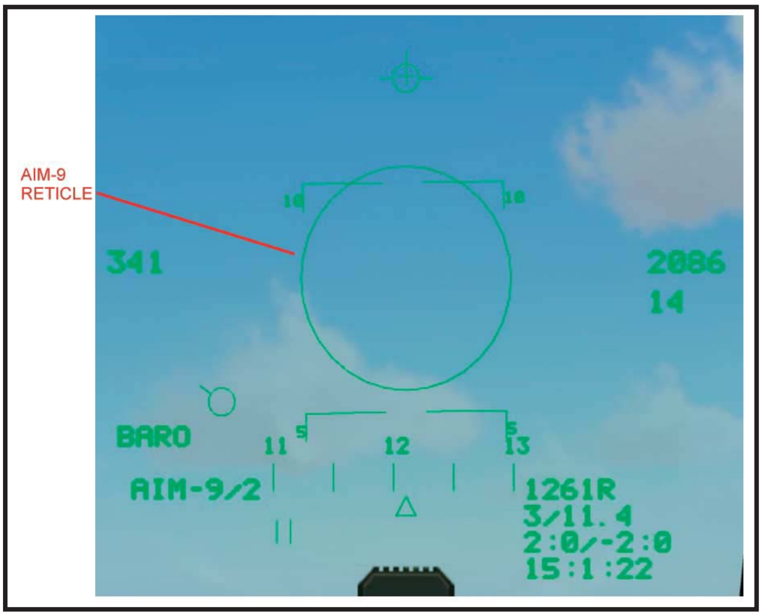



CCIP Bombing HUD

- The bomb pipper indicates where free-fall bombs released right now will strike the ground.
- The pipper includes an analog range scale that counts down counterclockwise. If the range bar exceeds the maximum-range tick mark, then the position under the pipper is too far away. Any bombs released will fall short of the target. For free-fall bombs, maximum effective range depends primarily on the altitude and airspeed of the launching aircraft.
- The bomb fall line stretches across the HUD from the gun to the bomb pipper.

## 3.205 Air-to-Air HUD

The air-to-air HUD provides targeting information for AIM-9 heat-seeking missiles. If the cannon is selected in this mode, an air-to-air gunnery funnel is displayed. The basic HUD is identical to other weapon HUDs, with the following additions:




A-10 Air-to-Air HUD

- With the AIM-9 selected, a circle is shown in the center of the HUD representing the missile's field of view. To lock the weapon, steer the aircraft to bring the target within the circle. Once locked, the target must remain within the circle or the lock is lost. Uncaging the seeker head allows it to move freely and attempt to follow the target.
- Selecting the cannon brings the low-aspect gunsight funnel to the HUD. The funnel provides an estimation of a target's range. The funnel is calibrated against the typical wingspan of a fighter-sized target. Maneuver the target aircraft into the funnel. Pull sufficient lead until the wings of the target just touch the both edges of the funnel. For fighter-sized targets, this should be the appropriate lead angle to ensure the rounds strike the target. Larger-than-average or smaller-than-average targets require manually estimating the required lead angle.

## 3.3. Su-27 and MiG-29 HUD Modes

## Introduction to Avionics & Combat Systems

LOMAC offers a complex and realistic portrayal of the real-world avionics suite found in the Su-27 and Su-33. By Western standards, these systems are generally regarded as inadequate, creating high pilot workload. To get the most out of the Flanker, you must learn how to operate its systems and how to cope with its design limitations.

All HUD displays fall into one of three categories: navigation, air-to-air combat, or air-to-ground combat. Submodes organize and display different types of information. Generally speaking, it's not necessary to utilize every submode for each category; however, each submode is designed for a particular task.

### Russian vs English Displays

To create the most authentic simulation of a Russian aircraft, all displays and HUD indicators default to the Russian language with Cyrillic characters. You may, however, switch the displays between English and Russian in the Options menu under "miscellaneous." Please note: Regardless of the language used, all displays will still use metric units. Altitude is measured in meters, and airspeed is measured in kilometers per hour.

## Navigation

The navigation modes are your primary means of finding your way around the simulated battlefield. There are four navigation submodes.

| Russian Designation | Pronounced | English Designation | Mode Type | Purpose |
|---|---|---|---|---|
| НАВ | "nav" | NAV | Piloting | Visual navigation with a compass and stopwatch |
| МАРШ | "marsh" | ENR | Enroute | Enroute navigation |
| ВОЗВ | "vosv" | RTN | Return | Return to the Initial Approach Fix at the home airbase |
| ПОС | "pos" | LNDG | Landing | Activates the Instrument Landing System (ILS) and autoland feature (for carrier operations) |

To select the navigation category, press the 1 key. This selects the default navigation mode, Piloting. Cycle through the various individual navigational submodes by hitting the 1 key repeatedly.

## НАВ—(NAV) — Piloting Submode

The piloting mode is the initial navigation submode, automatically displayed whenever you first press the 1 key while in another mode. This mode provides only minimal information. The HUD shows airspeed, altitude, and flight attitude information while the MFD shows airfields and the Admiral Kuznetzov aircraft carrier, if present. Use this mode for free-form flying without any pre-determined plan.


The НАВ (NAV) - Piloting HUD

## МАРШ (ENR) - Enroute Submode

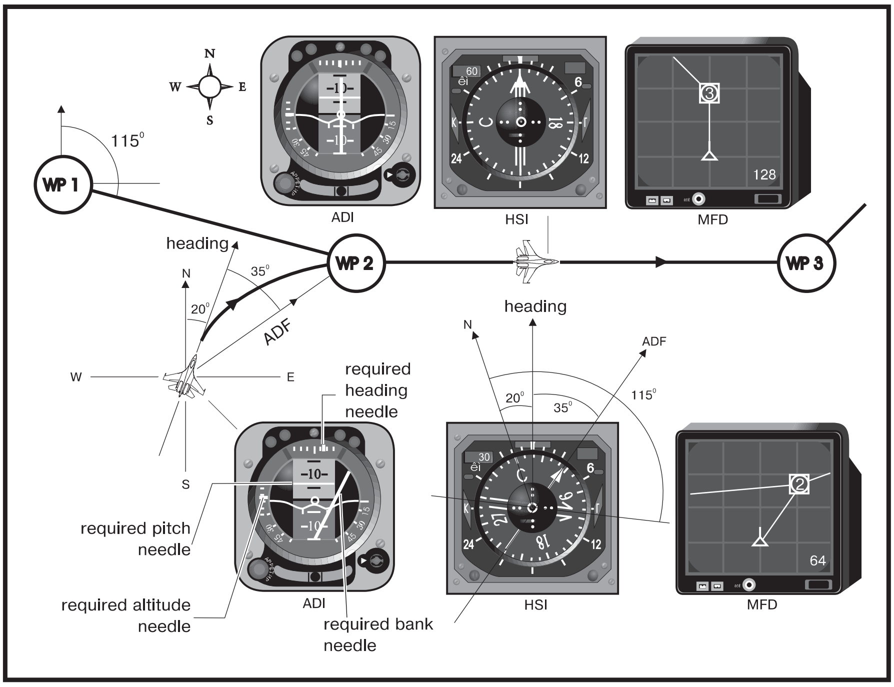
The **МАРШ** (ENR) submode is the primary navigation submode, enabling the pilot to fly the pre-determined mission flight profile. Select it by pressing the 1 key while in the initial NAV or piloting mode. Each waypoint is characterized by its coordinates on the ground, its altitude, and the desired airspeed for that leg of the trip. This mode displays the required speed and altitude of the waypoint in small characters located above the actual speed and altitude readouts of the aircraft. A circle or navigation reticle inside the HUD points the way to the next waypoint. Maneuver the aircraft to center the navigation reticle in the HUD and you're heading directly to the next waypoint. Numbers in the center of the HUD's bottom edge indicate the distance to the next waypoint in kilometers.


The МАРШ (ENR) Submode

## Backup Instruments

The instrument panel also provides navigation information. The MFD symbolizes your position, the waypoint , and the desired flight path to the next selected waypoint. The ADI yellow predictor bars ("needles") mark the desired bank and pitch angles while the HSI shows the required heading and distance to the next waypoint. In general, if the HUD becomes unserviceable, you can still navigate using the instrument panel.

The **МАРШ** (ENR) submode provides no combat information. Generally speaking, select this mode, set your course, and then select a more appropriate combat mode. Occasionally return to **МАРШ** (ENR) mode to verify your flight path. Press the ~ key to cycle through waypoints.




Reading the МАРШ (ENR) Submode instrumentation

In the figure above, the aircraft on approach to waypoint 2 is misaligned by about 35° to the left. This is reflected on the HSI (see the instruments at the bottom of the figure): the current heading is 20 and the ADF arrow (the narrow needle) reads 55°. The distance to waypoint 2 is 30 km (upper-left corner of the HSI). The desired radial, the desired flight path from waypoint 1 to waypoint 2, is shown by the flight path marker (the wide needle). In other words, the ADF needle points directly to the next waypoint while the flight path marker points to the pre-programmed flight path to that same waypoint.

The ADI also shows the misalignment between the aircraft's heading and the next waypoint. The required bank needle points to the right, indicating the aircraft needs to turn to the right to reach the next waypoint. If the aircraft were on course, the needle would point straight up. The required altitude needle on the left of the ADI shows that the aircraft is quite close to the desired altitude.

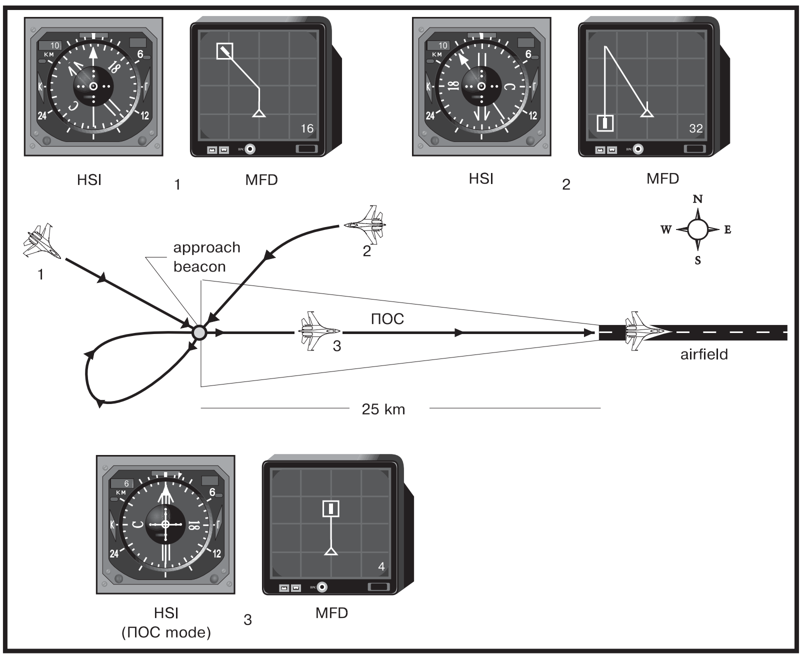
If the aircraft is on the planned flight path, as is the aircraft between waypoints 2 and 3 in the same figure, then the wide and narrow arrows on the HSI are aligned and pointing straight up. Likewise, the required bank needle on the ADI is also pointing straight up.

## BO3B (RTN) - Return Submode

The **BO3B** (RTN) submode directs you to the Initial Approach Fix (IAF) for the runway you are landing at. Think of the IAF as the last waypoint before reaching the airbase, where you will intercept the Instrument Landing System (ILS) and begin your approach. For all intents and purposes, **BO3B** (RTN) is identical to **МАРШ** (ENR) except that **BO3B** (RTN) only has one waypoint: the IAF for the runway.

The BO3B (RTN) - Return Submode

You select the **BO3B** (RTN) submode by pressing the 1 key twice from the initial NAV mode. You may cycle through the available runways and their IAFs by pressing the ~ key.



Reading the BO3B (RTN) - Return Submode Instrumentation

When flying towards the IAF, the wide arrow on the HSI always indicates the bearing from the beacon to the selected airfield and normally is the same as the runway heading. The figure above illustrates the readings of the HSI and the MFD for three aircraft with different positions relative to the approach beacon. Aircraft 1 is 10 km from the beacon and flying a heading of 135, on track to the IAF. Aircraft 2 is 10 km from the IAF, flying a heading of 270. The misalignment between the current heading and the required heading is 35°. In other words, the pilot must turn 35° to the left to fly directly to the IAF. Aircraft 3 is flying the runway heading, between the runway and the IAF. In this case, the MFD shows only a straight line from the runway to aircraft marker.

When the aircraft reaches the IAF, the navigation software automatically switches to the **ПОС** (LNDG), or landing, submode.

### я (LNDG) Landing Submode

You can, however, switch directly to landing submode by pressing the 1 key repeatedly until the GJC (LNDG) indicator is displayed on the HUD. If the airfield is equipped with an ILS, the Glideslope and Localizer bars are displayed. A vertical velocity scale will appear on the right side of the HUD. The ideal touchdown should occur at a sink rate of 1 to 1.5 m/s.


The ПОС–(LNDG) Landing Submode with ILS

## Radar and Electro-Optical System

The weapons control system (WCS) of the Su-27 and the Su-33 integrates the weapon and target data and parameters from the following components:

- The Zhuk-27 or Miech-33 airborne radar
- The 36-Sh Electro-Optical System (EOS)
- The onboard weapons management software
- Individual weapon targeting hardware and software
- The data presentation system (MFD and the HUD)
- The Parol (Password) Identification Friend or Foe (IFF) interrogator, which processes signals from air and ground installations equipped with pertinent transponders
- The Helmet-Mounted Target Designator (HMTD)
- Target data feed from AWACS

### Zhuk-27 Radar (Su-27and SU-33)

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 of up to 24 contacts
- Track While Scan of up to 8 contacts

Radar Cross Section (RCS) of the target, or the size of the reflecting surface of the target, has a substantial impact on radar detection performance. In general, large targets reflect more radar energy, so a B-52 can be detected farther away than an F-16. For a target with an effective RCS of 3 $m^2$ (a typical-sized fighter), the Zhuk-27 has a maximum detection range of 150 km (93 miles) when facing the target's forward hemisphere and 55 km (34 miles) when facing the target's rear hemisphere.

The radar transmits radio pulses of nearly equal frequency (within the X-band) and phase (coherent radiation). The radar measures the range to the target by timing how long it takes for the reflected waves to return to the transmitter. The greater the range, the longer it takes the waves to return. When the pulses are reflected from a moving target, the frequency shifts due to the Doppler effect. Pointing the radar at the ground, naturally, results in lots of radar reflections appearing on the scope. These returns are called ground clutter. Most modern radar systems take advantage of the Doppler effect and filter out any returns that are stationary, thus filtering out the extra returns from ground clutter. This does have one side effect, however, an airborne target that has no movement relative to the transmitter appears stationary and is filtered out. This condition typically occurs when the target moves perpendicular to the transmitter, and therefore appears stationary (in terms of how fast the transmitter is closing on the target). This effect is called "beaming" and is an effective defense against airborne radars.

You toggle the radar by pressing the I key. The Radar Cue **И** (Russian "I," stands for "illumination") on 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 the latter is damaged.

## 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 high accuracy. It combines a laser rangefinder (effective tail-on range of 8 km/5 miles) and Infra-Red Search and Track (IRST) system (maximum effective range of 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 (-15° down and +60° up) and in azimuth (60° left and 60° right of center, respectively). The information update rate depends on the field-of-view size and varies from 2 (search in wide area) to 0.05 (autotrack mode) seconds.

The EOS operates passively (emits no detectable signal) by receiving infrared emissions from the target. This allows the pilot to prepare a surprise attack on the enemy. Maximum detection ranges depend 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). In order to measure distances outside laser range when a target is locked (Tab key), the radar sends short strobe bursts or pulses towards the contact. Once the contact comes within 9 km, the strobe pulse ceases and the laser rangefinder takes over. These pulses are extremely short and difficult to detect with accuracy, thus providing little opportunity to locate the source. 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 gun fight.

To toggle the EOS, press the O key. The EOS Cue **T** (stands for "Thermal") on the left side of the HUD indicates that the EOS is active. If the EOS Cue does not appear at all, this indicates that the EOS is either damaged or not correctly selected.

The EOS, radar, or a 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 out distinctions as needed.

### Scan Cone Basics

To understand how the radar/EOS searches for targets, imagine walking through a forest with a flashlight on a pitch-black, moonless night. You can only see objects illuminated by the flashlight beam, and the beam grows weaker as it extends from the light bulb. This essentially describes the problems of using radar to search for targets. In simple terms, the radar extends something like a cone in front of the transmitter. The farther it goes, the bigger the cone gets. Objects outside of the cone will pass undetected. As a result, it is necessary to turn the aircraft occasionally and to "slew" the scan cone using the command keys on the facing page.

Objects inside the cone will reflect radar energy back toward the transmitter, but radar waves lose power as they travel. If they travel far enough, they eventually dissipate. Consequently, contacts at long range may not reflect enough radar energy; the reflected waves dissipate before making it back to the transmitter. Therefore, if the radar energy can travel 150 km, bounce off a target, and return 150 km to the source, then the radar energy is also capable of travelling at least 300 km in a straight line. This means that the enemy can detect your radar transmissions from well outside of your effective search range!

The EOS works similarly, except that it is a passive system; instead of looking for reflected radar waves, it looks for heat emitted by targets. As a general rule, hotter targets (fighters using afterburner) can be detected further away. Also, rear-aspect targets (with the heat source pointed at the EOS) will generally be detected further away than nose-aspect targets (since the enemy aircraft is blocking the view of the engine exhaust).

## Air-to-Air Combat

During an attack on an airborne target, the pilot usually goes through the following steps: search, locate, track, identify, and attack. He can accomplish these steps both with and without the radar and/or the Electro-Optical System (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 EOS.

The table below is a summary of the keys you will often use in air-to-air combat.

| Key | Action |
|---|---|
| I | Toggle radar |
| O | Toggle EOS |
| Tab | Place designated contact in Track While Scan from Scan |
| Ctrl-Tab | Remove tracked contact from Track While Scan |
| Tab | Lock tracked target to Attack Mode |
| Tab | Lock/unlock target to Attack Mode in CAC submodes |
| ; (Semicolon) | Move HUD target designator UP |
| , (Comma) | Move HUD target designator LEFT |
| . (Period) | Move HUD target designator DOWN |
| / (Slash) | Move HUD target designator RIGHT |
| Shift + ; (Semicolon) | Move radar/EOS scan zone UP in BVR modes |
| Shift +, (Comma) | Move radar/EOS scan zone LEFT in BVR modes |
| Shift +. (Period) | Move radar/EOS scan zone DOWN in BVR modes |
| Shift + / (Slash) | Move radar/EOS scan zone RIGHT in BVR modes |
| Ctrl+I | Center radar antenna/ IRST ball |
| -(Minus) | MFD/HUD Zoom in |
| +(Plus) | MFD/HUD Zoom out |
| D | Cycle through weapons |
| C | Enable/disable cannon |
| Ctrl+V | Toggle Salvo mode |
| Ctrl+W | Jettison weapons/Load Weapons, step-by-step |

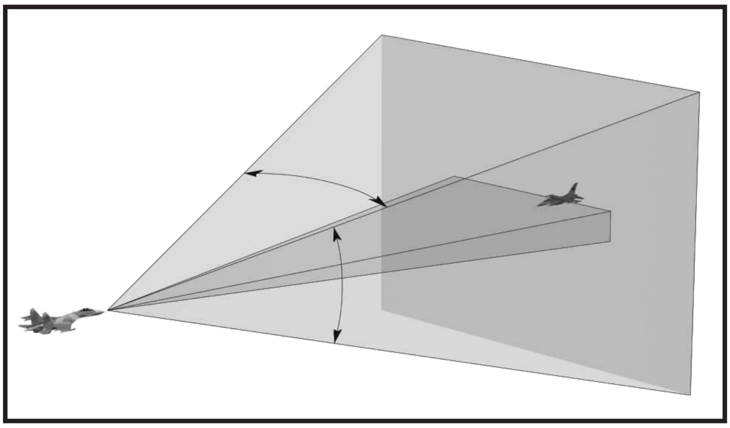
## Air-to-Air Mode Summary

The following table lists the different avionics modes available for air-to-air combat. Note that they fall into three categories: beyond visual range, close air combat, and longitudinal missile aiming.

| Flight / Combat Mode | Russian | English | Key | Purpose |
|---|---|---|---|---|
| Beyond Visual Range - Scan | ДВБ-ОБЗ | BVR – SCAN | 2 | Acquire up to 24 targets at 25 km to 150 km ranges |
| Beyond Visual Range -Track While Scan | ДВБ-СНП | BVR -TWS | 2 | Tracking up to 8 contacts while scanning up to 16 more |
| Beyond Visual Range - AWACS Datalink | ДВБ-ДРЛО | AWACS | 2 | Using AWACS information for attacking targets when radar and EOS is off – (requires AWACS) |
| Close Air Combat – Vertical Scan | БББ-ВС | CAC – VS | 3 | Dogfight at ranges from visual to 25 km |
| Close Air Combat – Radar Bore Site | БВБ-СТР | CAC – BORE | 4 | Aim using forward looking boresight of radar beam |
| Close Air Combat – Helmet | БВБ-ШЛЕМ | CAC – HMTD | 5 | Aim using helmet-mounted target designator |
| Longitudinal Aiming | ФИО | LNGT | 6 | Aiming using a missile's seeker at ranges from visual up to max IR/active range of missile |
| Attack | ДВБ-АТК<br>БВБ-АТК<br>ФИО-АТК | BVR-ATK<br>CAC – ATK<br>FIO – ATK | Tab | Auto-tracking one target (Target Locked) |

## ДВБ (BVR) Beyond Visual Range Mode

In **ДВБ** (BVR) Beyond Visual Range mode, both the radar and the EOS scan in a limited area - the scan cone 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 radar/EOS scan zone within the gimbal limits of the antenna/seeker. The scan zone dimensions of the radar are 120° x 120° , the EOS dimensions are 120° horizontal, 60° up and 15° down (see the figure below). The radar beam scans an area 2.5° tall, requiring four passes to cover the entire scan cone. Each pass takes about 0.5 seconds. Information on each radar contact, therefore, is updated every two seconds.



In BVR mode, the radar antenna is stabilized 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 maneuvers do not 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-sized 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 150 km.

| Target | Maximum Detection Range in Scan Submode, Km |
|---|---|
| B-52 | 150 |
| F-111 | 80 |
| F-16 | 50 |
| F-117 | @10 |

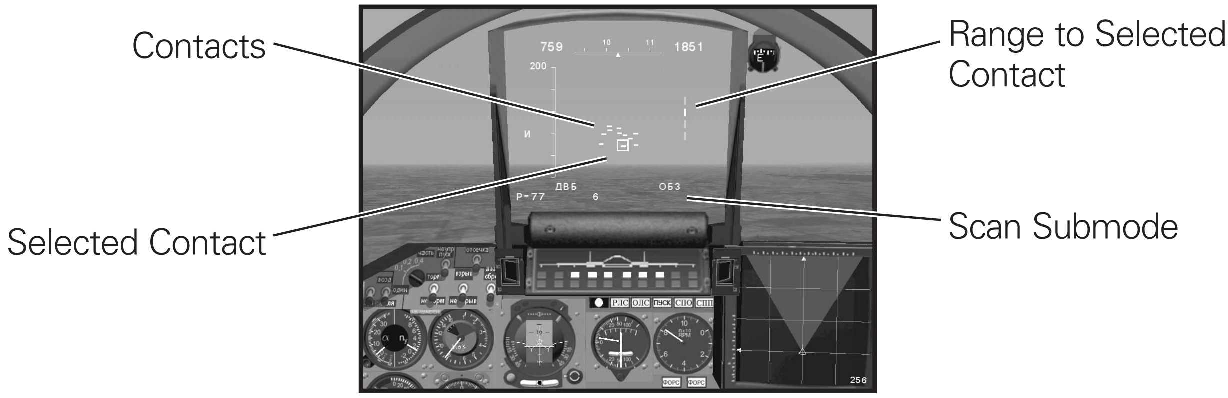
As with the radar, the field of search of the electro-optical system is stabilized in roll and pitch. The EOS can detect medium-sized targets located up to a maximum of 50 km, but, as described above, cannot accurately measure the range to a target beyond 5 km.

Tracking data appears on both the HUD and the MFD, depending on the mode and submode selected. In most cases, the MFD shows a top-down view of the area around your aircraft. Your current position is indicated by the small aircraft symbol; the number in the corner indicates the distance from the bottom edge to the top edge in kilometers. HUD and MFD symbology appropriate to each mode and submode are described in the following sections.

ДВБ (BVR) mode has two submodes of operation: Scan and Attack. The following sections describe each mode.

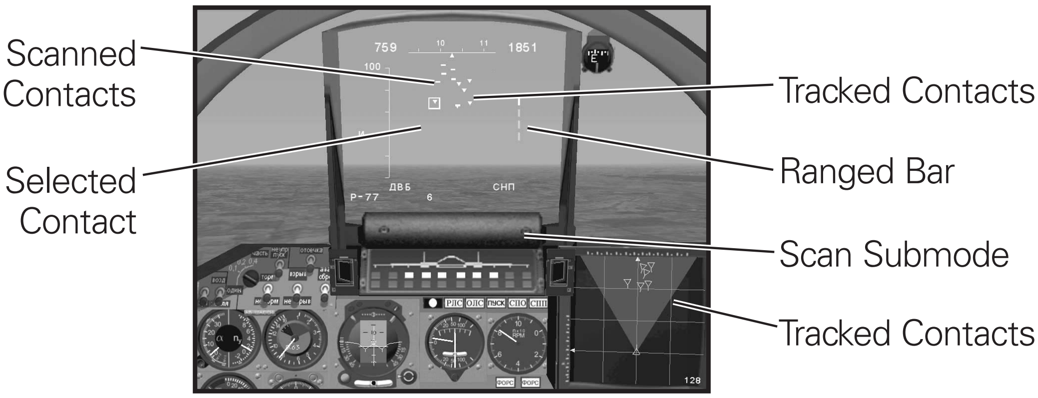
## ДВБ – ОБЗ (SCAN) Scan Submode

Pressing the 2 key selects ДВБ (BVR) mode in the ОБЗ (SCAN) submode of operation. This is your primary, long-ranged search mode. It detects contacts (depending on RCS) from 25 to 150 km away, displaying up to 24 contacts on the HUD. This mode does not provide any detailed information about a specific contact. You'll know the azimuth (how far the contact is off your nose) and distance. You can also establish the contact's elevation by the correlating image return and scan beam "illuminator" on the right side of the HUD.




ОБЗ (SCAN) Submode

To gather more information about specific contacts of interest, steer the HUD target designator box over the desired contact (using the joystick coolie hat or the keyboard controls). Designate the target by pressing the Tab key.




СНП Submode

## Attack (ATK) Submode

The Attack submode is common to all air-to-air modes. In short, you are requesting the radar to focus all its energy onto one specific aircraft contact.

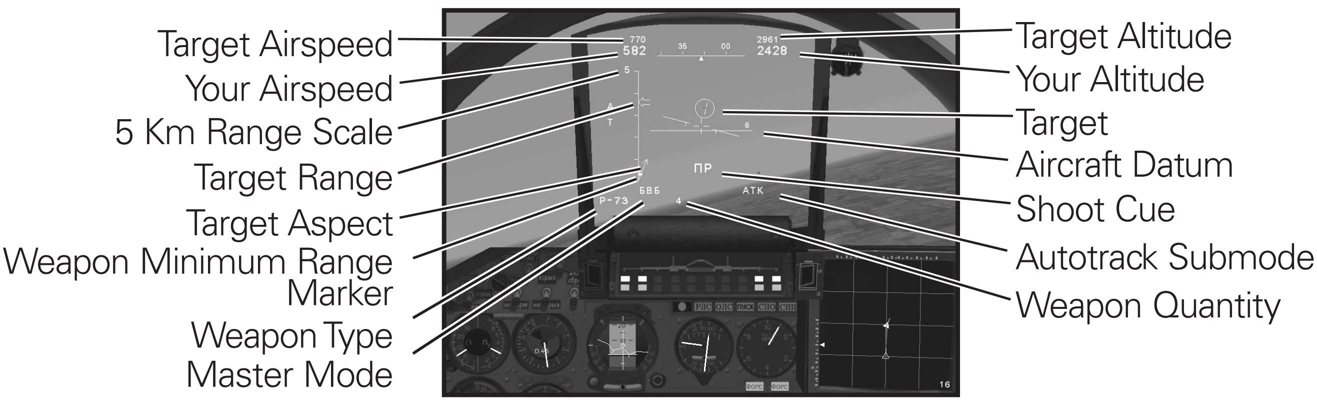
Depending upon which mode you are operating (BVR, CAC), the method of selecting or designating that contact differs, but the end result is the same: The radar/EOS will automatically track the aircraft contact, hence the term "auto-track." In common language, this is called "the lock." The radar/EOS receives all the necessary contact parameters from the Weapons Control System to smoothly move the antenna in the direction of flight for the contact. The following parameters are available on the HUD while the radar is in auto-track:

- Aspect angle relative to user aircraft
- Azimuth/Elevation relative to user aircraft
- Distance relative to user aircraft
- Speed of contact

The radar tracking area for a single target is 120° x 120° in elevation and in azimuth, and tracking range for a medium-sized target is from 55 km (rear hemisphere) to 100 km (forward hemisphere for large aircraft). When operating in Attack mode, the radar provides target designation for guided missiles, illuminates targets for missiles fitted with SARH seekers, and provides initial guidance data for active missiles.

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, strength of the heat signatures, and the attack hemisphere. The EOS laser rangefinder measures distances to the target for ranges from 0.2 to 3 km, with an accuracy of 10 meters and from 3 to 5 km with an accuracy of 25 m.

After the radar (EOS) has locked onto the target, the HUD shows the following information: the "À" Autotrack Cue, the range scale with the minimum and maximum launch range marks, the range-to-target mark, 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 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).

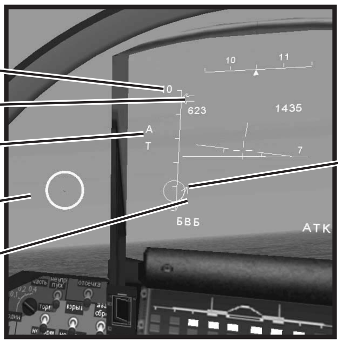



Autotrack Symbology with Radar Lock

Green lights on the weapon readiness panel indicate which missiles at each weapon station are ready for launch. The MFD displays a top-down view of the target, its aspect angle, and distance 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.

The HUD will also display the ПР Shoot Cue or OTB Reject Cue (pronounced "o-te-ve," stands for "Turn Away" in Russian). In English, the Shoot Cue designator is LA for "Launch Authorized," and the Reject Cue designator is No LA for "No Launch Authorized." 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 (Space Bar). The Reject Cue warns that you are too close to the target and prohibits launch. If you lock onto friendly aircraft, the IFF will detonate СВОЙ, meaning "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 common when using the EOS).




4-17: Autotrack Symbology with Helmet-Mounted Sight

When tracking a target in Attack mode, maneuver your aircraft so that the Aiming Reticle stays close to the HUD centre datum. This eases your workload 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. After launch this will be represented by the A (Autotrack) Cue flashing at 1 MHz. So know your missiles!

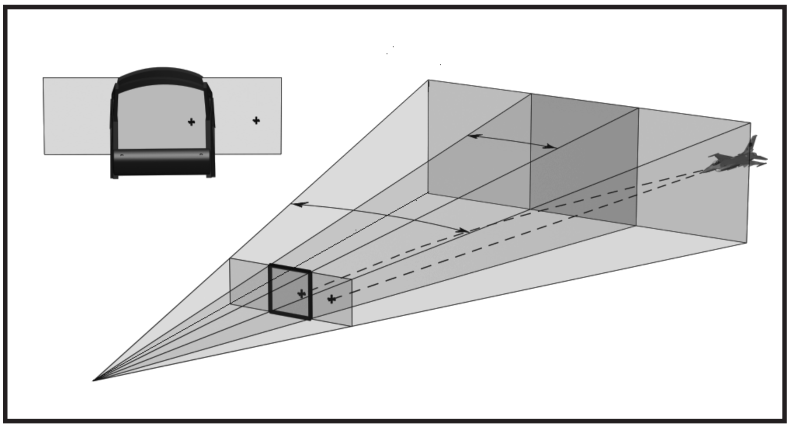
If the target leaves the tracking area, or you break the lock by pressing the Tab key, or the target is destroyed, the radar (the EOS) returns to the submode that preceded the Autotrack. Similarly, if the radar or EOS is damaged or you switch sensors off, the lock breaks and the radar returns to the submode that preceded the Autotrack.

## ДВБ – ДРЛО (AWACS) AWACS Datalink

The Flanker's ability to datalink with AWACS aircraft allows pilots to locate and stalk targets without ever engaging onboard sensors. This form of "stealth" lets the Flanker close on its prey without betraying its presence. A friendly AWACS aircraft (an A-50 or E-3) must be airborne simultaneously to your aircraft. The datalink information can be viewed on the MFD in all combat modes as well as the NAV modes; however, these contacts can only be selected for targeting from the BVR mode. While in BVR mode, if there is a friendly AWACS aircraft airborne, a datalink will be established, and contacts detected by the AWACS will appear on the MFD as standard aircraft symbols (friendly and enemy). The AWACS contacts will appear more subdued (less bright) than regular contacts. Turn on radar at least once to establish data link.

ДРЛО (AWACS) Submode

## HUD Scaling Considerations


Target Positions are Scaled to Fit the HUD

Keep in mind that the scan zone for submodes is larger than the area covered by the HUD. Targets are therefore "scaled" to fit the dimensions of the HUD. The target marker in the HUD, consequently, points toward the target but is not an accurate indicator of the target's azimuth and elevation. The gimbal markers on the MFD will give you a better idea as to how close the gimbal limit for the target is, and you will easily interpret off-boresight angle.

## Acquiring a Target in ДВБ (BVR) Mode Step-by-Step

Let's walk through the process of acquiring a BVR target.

**Step 1. Switch to BVR Mode.**

Press the 2 key and check that the HUD Mode Indicator shows the notation of the **ДВБ – ОБЗ** (BVR - SCAN). If there is a friendly AWACS aircraft airborne **ОБЗ** (SCAN) will be replaced by **ДРЛО** (AWACS). Use the + and – keys to adjust the range displayed on the MFD and the HUD.

If you have an AWACS datalink, then you will almost immediately receive contact data on the MFD: Friend or foe, distance, and aspect angle. (See above for more on AWACS). If this is the case, you can cycle through the contacts on your MFD by selecting the tilde (~) key. Then go to step 5.

**Step 2. Select a Sensor.**

Activate the radar or EOS. The notation at the left of the HUD should read **И** (I) or **Т** (T) for the radar and EOS, respectively. Alternatively, the HUD will display **ДРЛО** (AWACS) if a friendly AWACS aircraft is airborne and in range.

**Step 3. Direct Scan Zone.**

Using the Shift - coolie hat on your joystick or the scan zone control keys, aim the scan cone in the portion of airspace you wish to scan. The HUD will immediately show detected contacts, if any.


The ОБЗ (SCAN) Submode Symbology

**Step 4. Locking up the Target.**

To select a particular target, steer the HUD Target Designator Box (HTD Box) onto the contact of interest and press the Tab key. The contact will switch from being scanned to tracked. This method is called "manual selection," since you are selecting an individual contact to be tracked by the radar.

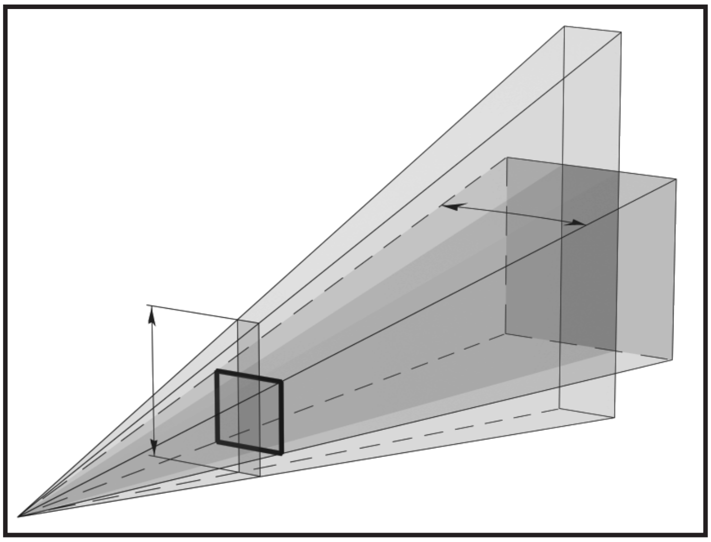

The СНП Submode Symbology

**Step 6. Select Air-to-Air Missile and Launch.**

Select the appropriate air-to-air missile for the range and type of target by pressing the D key. Consider range, maneuverability, size, and speed of the target. Once the target is within the launch parameters of the weapon and the Launch Cue is displayed in the center of the HUD, you are authorized to fire the "weapon."

## БВБ /Close Air Combat Mode

The БВБ (CAC) Close Air Combat mode is used for attacking targets that you have spotted visually or that 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° x 20° (±10° in azimuth and ±10° in elevation). The ШЛЕМ (HMTD) submode permits the pilot to acquire targets with greater off-boresight angles.



The БВБ Scan Cone

## БВБ-ИС (VS) Vertical Scan Submode

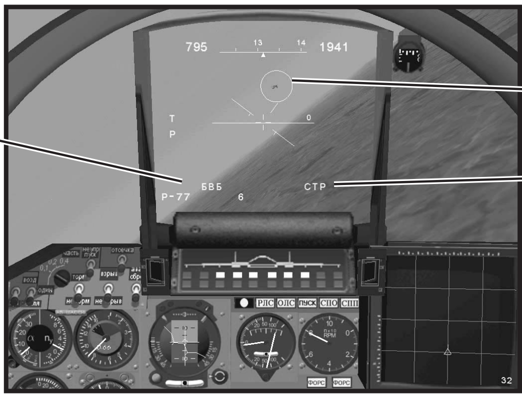
The first submode, called Vertical Scan submode, is depicted on the HUD by a narrow vertical band. This submode can be selected by pressing the 3 key. It is designed to acquire targets in a dogfight. Both radar and EOS are active, but this mode is very stealthy, as the radar is not constantly emitting. It is “primed” and ready in a standby mode, ready to send a very strong and fast scan along the 25∞/60∞ Vertical Scan cone. The HUD will display a P (which is the Russian R) on the left side of the HUD to denote “ready” or standby, as well as the T for the EOS. Any contact detected and designated (locked) within the cone will immediately stop the scan process and focus a 2.5∞ circular beam on the target, switching the submode to Attack (ATK).

Maneuver your aircraft so as to position the visually acquired target within the limits of the Vertical Scan Bar portrayed in the center of the HUD. The actual scan cone extends 20∞ above and behind the HUD. This means that you can lock a target even if you position it within that imaginary extended band. You can also steer the Vertical Scan cone (band) left and right 10∞ by using the target designator key commands.


The Vertical Scan Mode Close Air Combat Symbology

## БВБ-СТР (BORE) Boresight Submode

The second submode, entitled Radar Boresight, scans in a narrow 2.5∞ circular beam, which can be steered up, down, left, and right (using the target designator controls) within the angular limits of the HUD, 20∞ x 20∞. This mode is used to focus the radar on a specific target, and is especially useful in crowded airspace. Activate the **СТР** (BORE) submode by pressing the 4 key. By steering the beam directly to the desired target, you reduce the risk of accidentally locking the wrong target. Similar to the Vertical Scan submode, the radar is not illuminating continuously but is on standby and primed to send out a strong circular pulse to the target. If the radar receives a return pulse, the system switches immediately to Attack mode.




The Boresight Mode Close Air Combat Symbology

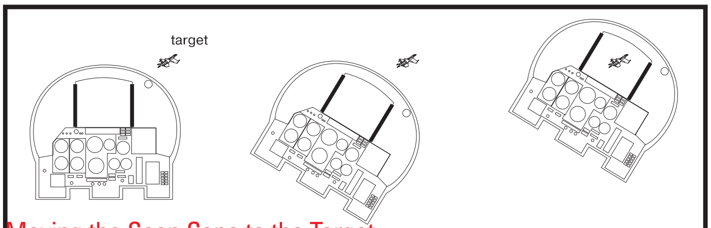
## Acquiring a Target

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

**Step 1. Switch to CAC Mode.**

Press either 3 or 4 to select the desired **БВБ** (CAC) submode. Make sure that the HUD mode indicator shows the **БВБ** (CAC) notation.

**Step 2. Select a Target.**



Moving the Scan Cone to the Target

Once you have visually spotted a target, place it in the field of view of the HUD by maneuvering your aircraft and/or Vertical Scan or Boresight scan cones.

**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. You may have to press Tab several times to obtain a lock.

## ШЛЕМ (HMTD) Helmet Mode

This is also a Close Air submode that, while visually similar to the Boresight submode, is very different. This submode can be activated by selecting the 5 key. The Helmet-Mounted Target Designation (HMTD) system frees the pilot from having to boresight his enemy by slaving the radar and the EOS to the helmet-mounted sight. Once you have acquired the target, the Helmet mode allows 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-world system works by using a pair of head position sensors on the cockpit panel, on each side of the HUD.

The radar (the EOS) locks onto the target in an area limited by the 2.5∞ scan cone. The pilot should keep the cone within 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 or the IRST sensor ball.

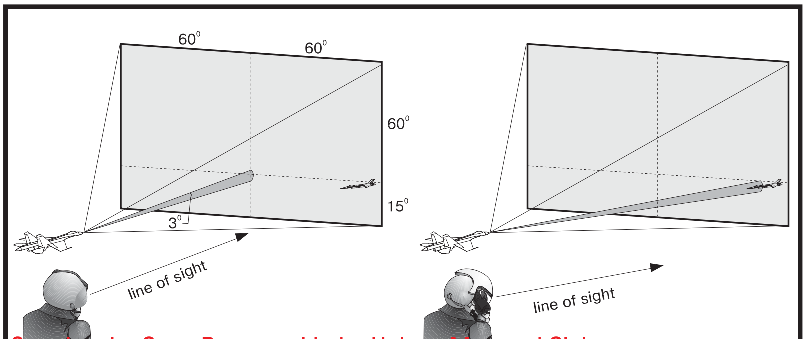
### Acquiring a Target

Use the following procedure to lock a target with the IKTV (HMTD) mode:

**Step 1. Switch to Helmet Mode.**

Press the 5 key. The HUD submode indicator displays the notation IKTV (HMTD) (pronounced "shlem," denotes "Helmet" in Russian) on the lower-right corner of the HUD. The targeting circle appears in front of you and follows the movement of your head.

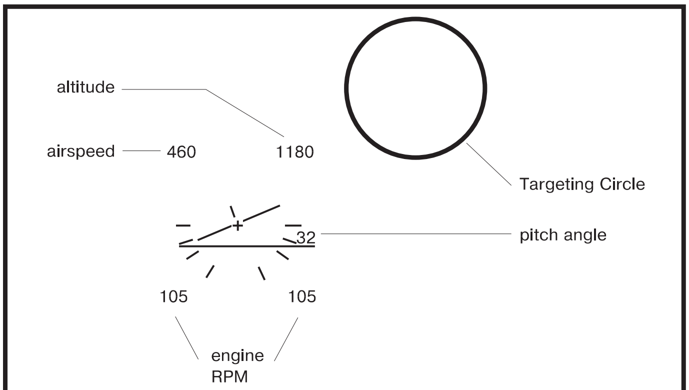
## Step 2. Select a Target.




Steering the Scan Pattern with the Helmet Mounted Sight

Once you have visually spotted a target, place it within the targeting circle by maneuvering 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 eyes onto the target, press * (asterisk) on the keypad.

## Step 3. Lock onto the Target.




Visual Steering Cues with the Helmet Mounted Sight

To place the HMTD onto the padlocked target, use either the joystick coolie hat or the scan cone keys. Once the circle is on the target, press the Tab key. The HMTD is now padlocked to the target (along with your eyes) and the weapons control system is put into the Autotrack mode.

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 above).

## ФИО/Longitudinal Missile Aiming Mode

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.

### Longitudinal Missile Aiming

You use the ФИО (LMA) mode for attacking a visible airborne target in a dogfight by selecting the 6 key. 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 ФИО (LMA) mode, perform the following steps:

**Step 1. Switch to Longitudinal Missile Aiming Mode.**

To do this, press the 6 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.


Longitudinal Aiming Mode Symbology

**Step 2. Select a Target.**

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

### Seeker Track Mode

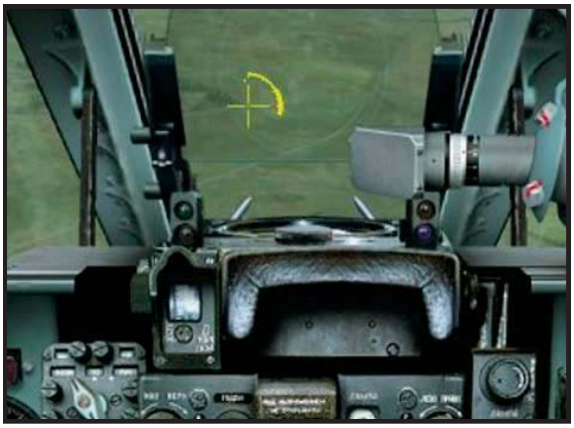
After a missile seeker has locked onto the target, it switches to track mode, continuously keeping the target within the seeker's field of view. The dimensions of the single target tracking area depend on the type of missile and are limited by the gimbal limits of the seeker head and sensor sensitivity. Gimbal limits may range from 20° (the R-60 Aphid) to 80° (the R-77 Adder). Tracking range depends on the type of target and specifications of the seeker head, and may vary between 5 km and 30 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 ABJ (LMA). Lock onto the target is evidenced by the movable aiming reticle showing an angular position of the seeker head, and by the Shoot Cue GH.

You should maneuver the aircraft so that the movable aiming reticle stays close to the HUD center 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 that immediately preceded the track mode ФИО (LMA).

## 3.4. Su-25 HUD Modes



The anti-radar missiles Kh-58 and Kh-25 MP are very easy to use; fly the nose of your plane towards the electromagnetic source and lock the target pressing the Tab key. The pipper will then center to the emission source, the distance to the target, and the minimun launch distance in the outer circle. Since these are fire and forget missiles, once launched you can look for another emission sources if you have enough missiles, of course.

The laser-guided missiles Kh25L and Kh-25ML are a bit more complicated to manage, as they need the pilot to manually designate the target. First, you need to establish visual contact with the target and begin a gradual descent. The auto-throttle feature can be very useful.

With the nose of your plane pointing at the target, turn on the laser pressing the 0 key. The pipper appears in the HUD, and you will need to move it over the target.  When it is over the target, pressing the Tab key will lock it. The pipper is now fixed at the selected point and shows us the slant range distance and the minimum launch distance indicators.

Information provided by the marks at the ring of the pipper:

### Dynamic Indicators

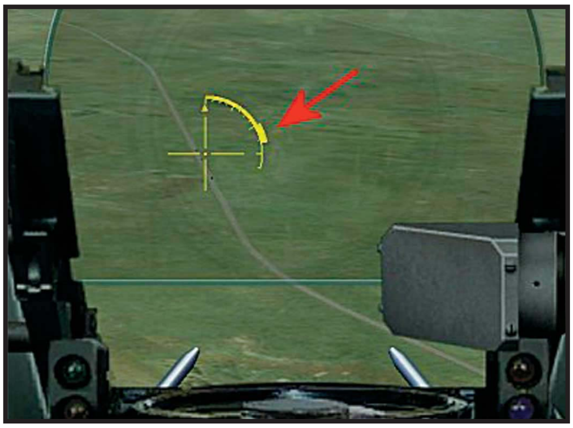
- The narrow arc is the slant range distance indicator (moves counter-clockwise).
- The wide arc shows the remaining distance to the minimum launch distance (moves counter-clockwise).
- The small triangle that you can see at twelve o'clock is a bank indicator.

### Static Marks

- Each long line indicates 1000 m of slant range distance to target.
- Each short line indicates 250 m of slant range distance to target.

Once locked, you can still move the pipper.  So it’s important to launch the missile well before we arrive at the minimum distance; we can continue making fine adjustments after that. Note that the wide arc disappears when we are at the minimum launch distance.

In the following two images you can see the launch sequence. At the left, note we are arriving at the minimum launch distance but we have the pipper in the correct position, so it's time to launch the missile. At the right image you can see how we continuously adjust the pipper after the missile has launched, to keep it over the targets, as they are mobile units.



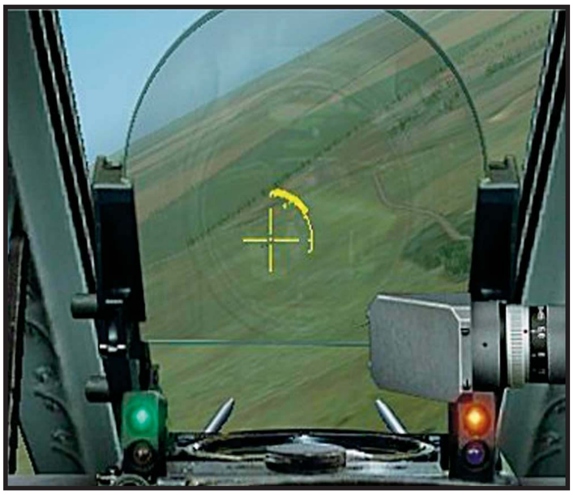
Attacking ground targets with rockets should be done with a stable approach to the target. Remember to activate the laser ("0" key) to get the correct indications from the pipper (a green indicator will light up). When in launch range, a red indicator will light up and the outer circle of the pipper will show the slant range distance.

## *Air to air attack mode*


Select Air-to-Air mode and check in the inventory panel that we have the short range defense missiles selected.

To attack with Air-to-Air missiles, it is enough to visually locate the target, lock on it with the Tab key and stay in range to shoot. The distance to the target is indicated in two ways: the red warning light below the HUD, which will turn on when in range, and the outer circle of the pipper (as said before, long lines mean 1000 m and short ones 250 m).

Attacking with guns is similar in simplicity; the important thing is to maneuver the plane to get a good fire position, obviously.



# SENSORS

In many aerial battles, the victim never saw the attacker. Technological advancements now let the pilot "see" targets as far away as one hundred miles. Radar, laser, and infrared sensors extend the pilot's view, giving "first look, first shot" capability.

## 4.001 Radar

Radar is an active sensor, meaning it broadcasts energy. This energy travels through the air, strikes targets, and is reflected back to the emitter. The radar measures how long it takes the pulse to return, the angle of the radar antenna, and the frequency shift of the returned pulse. Comparing multiple returns over time lets the radar calculate the target's range, altitude, speed, heading, aspect angle, and closure rate.

Radar is not perfect, though. As the pulse travels through the air, it loses energy. When it bounces off a target, it loses more energy. Traveling back to the emitting aircraft, it loses yet more power. Successfully detecting a target requires the return pulse having sufficient energy to be detected by the radar system. The more amount of energy reflected by the target is called the Radar Cross-Section or RCS. The larger the RCS, the farther away the target can be "seen."

**▶ The larger the object's RCS, the greater the range at which it can be detected.**

Modern radar relies on the Doppler Effect and the resulting frequency shift in the return pulse to glean information about the target. To minimize "clutter" caused by reflections from the ground, radar systems filter out stationary targets based upon measuring the Doppler shift in the return pulses. Unfortunately, this same mechanism filters out aerial targets flying perpendicular to the emitter. This is known as "beaming" the radar and is an effective tactic to break hostile radar lock ons.

**▶ "Beaming," or flying perpendicular to a radar emitter, is an effective tactic against Doppler-based radars.**

Radar does not cover the entire sky. Imagine searching for armed opponents in a large, darkened room filled with furniture with only a small penlight to guide you. The flashlight beam covers a very small percentage of the room, so you must move it around a lot to avoid obstacles and prevent the bad guys from sneaking up on you. Likewise, the radar system must move the beam as it scans the sky. However, the larger the volume of the scan pattern, the longer it takes the radar to complete a single scan. Fast-moving, nimble fighters might pass through the scanned area undetected if the scan pattern is too large.

Unfortunately, using a flashlight in a darkened room reveals your position to your adversaries. Likewise, radar emissions announce your presence to everyone around. Most modern combat aircraft carry Radar Warning Receiver (RWR) gear that listens for and analyzes radar emissions. By measuring the characteristics of the received pulse, the RWR can often identify the radar system and therefore identify the opponent's aircraft type.

Radars operate in a variety of modes, varying the rate pulses that are transmitted and the size of the scan pattern. The number of pulses emitted per second is called the Pulse Repetition Frequency (PRF). Radars in "searching" modes generally use larger scan patterns and a lower PRF, letting the radar monitor multiple targets. Radars in "tracking" combine small scan areas with a high PRF. The radar then reports significantly more information about one target, and continually adjusts the scan pattern to maintain focus on the target. This is commonly called a "lock on."

Many modern radar systems attempt to bridge the gap between search and track radar modes with Track While Scan (TWS) modes. TWS modes attempt to provide detailed tracking information about multiple targets while continuing to scan a large volume of airspace. On the positive side, this provides a substantially more thorough picture of the sky. On the downside, the radar must make "educated guesses" about the tracked targets, since the radar cannot focus attention on any single target. Based on information collected when the radar beam scans a given target, the radar predicts the target's flight path until the beam again scans that target. While the beam is busy scanning other targets, the radar display shows the predicted position of the first target. If that makes a sudden, unexpected maneuver, the radar display continues to show the predicted position until the radar beam finally returns its attention to the target and finds it gone.

**▶ TWS mode provides details for multiple targets simultaneously, but relies on estimations of the target's position, and can therefore be "tricked" if a target makes an unexpected maneuver.**

## 4.002 Infrared

Engines, especially jet engines, produce a lot of heat. Weapon designers quickly realized they could detect and track this heat, or *Infrared* (IR) energy. Early IR systems could only track targets from behind, with the hot engine exhaust pointed directly at the seeker. Modern all-aspect heat-seeking missiles can track the heat emitted from a target from any angle. Further, many aircraft carry Infrared Search and Track (IRST) systems, which can detect targets many miles away. IRST systems are passive, meaning they emit no energy of any kind. Unlike radar, which announces the emitter's presence to the world, IR systems are completely "stealthy" and impossible to detect.

**▶ Weather, such as rain and fog, seriously degrades IR performance. In severe weather conditions, IR systems suffer greatly shortened detection ranges.**

## 4.003 Laser

Laser systems provide modern combat aircraft with a third major sensor system. Laser rangefinders calculate distance very accurately by bouncing a laser beam off the target and measuring how long it takes the beam of laser light to return to the emitter. Ground-attack systems use lasers to pinpoint specific objects (such as an individual battle tank or a specific window on a building) to guide air-to-ground weapons. Since lasers, like radar, emit energy, laser emitters can be detected by hostile forces.

As with IR systems, laser systems work best in clear weather. Clouds, fog, and rain seriously degrade laser systems.

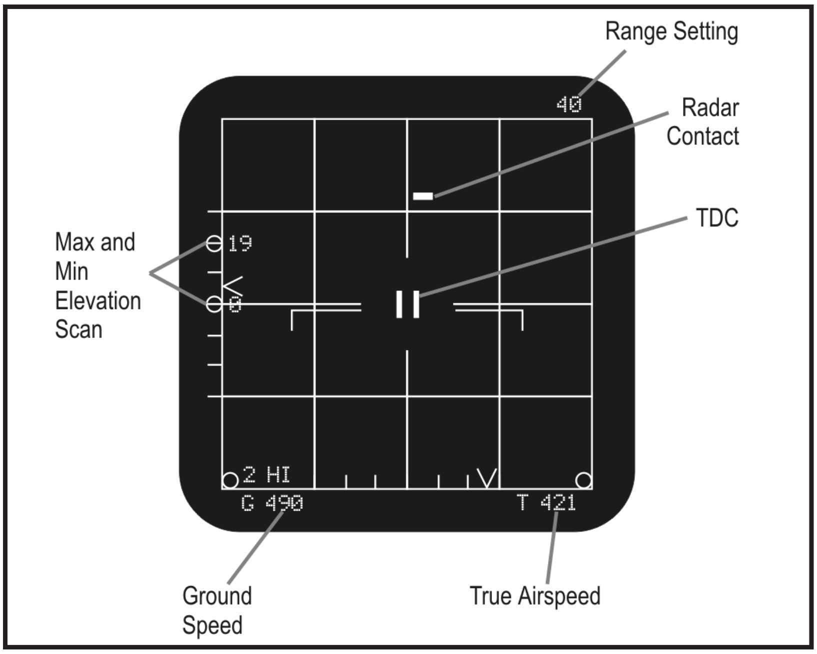
# 4.1. F-15C Eagle Radar Modes

## 4.101 Range While Search (RWS) Mode

RWS mode is the F-15C's primary, long-range search mode. The pilot specifies a maximum scan range (10, 20, 40, 80, or 160 nautical miles) and chooses the height and width of the scan pattern. The radar displays targets found within that volume of airspace, but does not provide detailed information about any given contact.

The VSD shows a top-down view of the sky, with the bottom line representing the aircraft's position and the top line representing the maximum search range (20, 40, 60, 80, or 160 nautical miles away). Contacts appear on the VSD based on their range; the closer they are, the farther down the display they appear. The VSD search range automatically adjusts to a lower or higher setting as contacts approach the bottom or top edges, respectively. Up to 16 contacts can appear simultaneously on the VSD. The radar automatically issues an IFF (Identify Friend or Foe) query when it detects a contact. Friendly contacts appear as circles; hostile and unidentified contacts are shown as rectangles.

The left edge of the VSD describes the height of the scan pattern, called the *elevation*. The height of the elevation is measured in 2.5-degree units called *bars*. The elevation may be set to 1, 2, 4, 6, or 8 bars in height. The two circles on the left side of the VSD move, representing the size of the elevation scan. The numbers next to the circles indicate the upper and lower altitudes of the scan pattern at the selected search range. Additionally, the entire scan pattern may be moved 30 degrees above or below the aircraft's center line. The elevation caret moves up and down indicating the current elevation of the radar antenna as it moves through the scan pattern.



RWS Mode

The lower edge of the VSD shows several pieces of information. The aircraft's ground speed (G) and true airspeed (T) appears below the VSD. The elevation bar selection appears in the lower-left corner of the VSD. The radar automatically interweaves high and medium Pulse Repetition Frequency (PRF) pulses through the scan pattern, displaying the current PRF value (HI, MED, or LOW) next to the elevation bar setting.

The bottom edge of the VSD also shows the scan pattern's width, called the *azimuth*. The azimuth may be set to either +/- 30° or +/- 60° wide. The circles along the bottom of the VSD move to indicate the current width of the radar scan pattern, and the azimuth caret moves between the circles, indicating the current horizontal position of the radar antenna.

**▶Larger patterns take longer to scan. Fast-moving targets can move completely through the pattern undetected before a radar beam reaches that portion of the scan.**

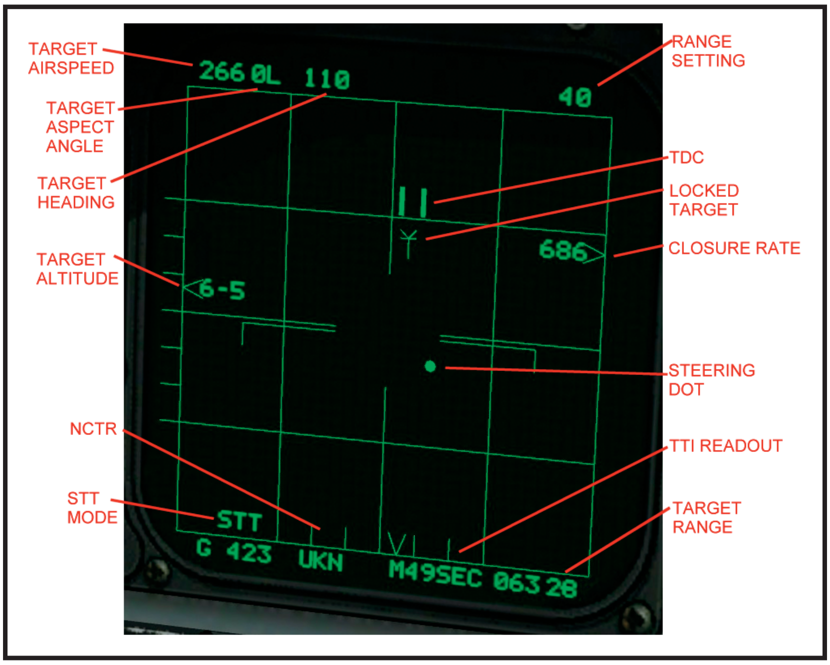
Two other indicators appear within the VSD. The aircraft waterline appears centered in the VSD, providing an indication of the aircraft's bank angle. This helps the pilot maintain control while concentrating on the VSD. Additionally, two parallel vertical bars, called the Acquisition symbol, let the pilot lock onto specific targets. Move the Acquisition symbol over a specific target, and press the Designate key to lock the target and switch the radar to Single Target Track mode.

## *4.102 Single Target Track (STT) Mode*

After radar-locking a specific target, the radar switches to STT mode. STT mode uses a fixed scan pattern centered on the specified target, displaying information only on that target and ignoring all other contacts. The basic VSD format remains identical to RWS mode, but substantially more information appears. The STT indicator appears in the lower-left corner. The Contact symbol changes to the Primary Designated Target (PDT) symbol.

**▶You must either lock a target and enter STT mode, or activate FLOOD mode in order to launch an AIM-7 missile.**

The *non-cooperative target recognition* system automatically attempts to identify the locked target. The target must be within 25 nautical miles and must be facing the player with an aspect angle between 135° and 225°. The aircraft type or "UNK" (for "unknown") will be shown below the VSD.



STT Mode

Target airspeed, aspect angle, and heading appear above the VSD's upper-left corner. The target's altitude MSL appears next to the elevation caret on the left edge. For example, 17,200 ft would be displayed as "17-2." The range caret appears along the right edge, with the target's closure rate displayed next to the caret. Numerical bearing-to-target and range-to-target values appear in the lower-right corner.

Significant missile targeting information dominates the VSD in STT mode. First, the Allowable Steering Error (ASE) circle appears in the center. The size of the circle depends on the currently selected missile type and the target's position, speed, heading, etc. Maneuver the aircraft to bring the steering dot within the ASE circle to maximize the missile's chances of intercepting the target.

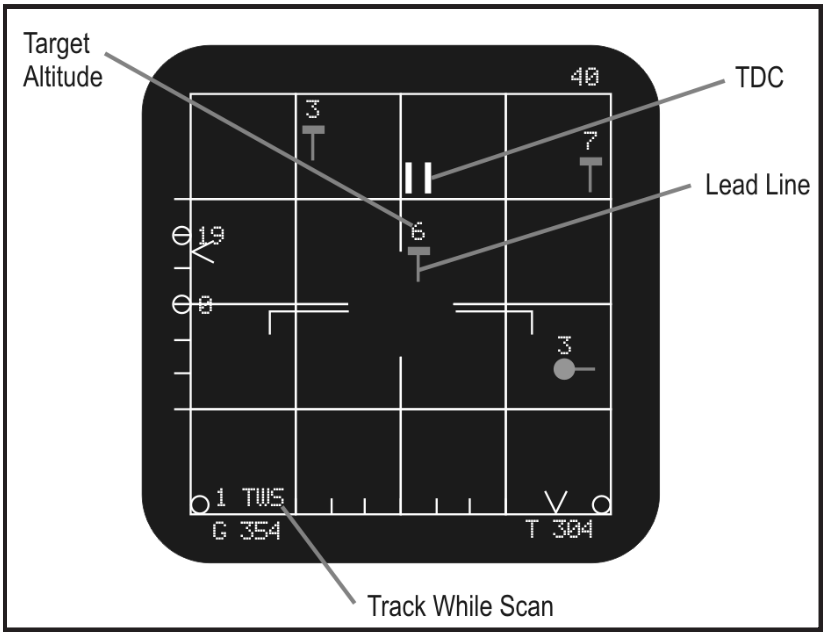
The Missile Range Cues RMIN (minimum launch range of the selected missile), the RTR (maximum range against a maneuvering target), and RPI (maximum range against a non-maneuvering target) indicators are shown along the VSD's right edge. Additionally, a triangle marks the RAERO, or absolute maximum aerodynamic range of the selected missile. The missile Shoot Cue, along the bottom edge, indicates when the target is within acceptable launch parameters. The Time-To-Intercept (TTI) counter shows the number of seconds a missile will take to reach the locked target.

After a missile launch, another timer appears along the top edge, next to the range display. After launching an AIM-7, the display shows a "T" and counts down the TTI for that missile. After launching an AIM-120, the display shows a "T" and counts down the Time-To-Active (TTA) for that missile. Once the missile goes active, the display shows an "M" and counts down the time until the missile impacts the target.

## 4.103 Track While Scan (TWS) Mode

TWS is a powerful, but somewhat difficult, radar mode. As the name implies, it combines elements of both RWS and STT modes. Using a fixed-size, unchangeable scan pattern, TWS provides detailed tracking data on multiple targets while continuing to scan the entire pattern. Initially, the TWS display is virtually identical to the basic RWS display, except the letters "TWS" appear in the lower left corner and the altitude (in thousands of feet MSL) appears above each contact. You cannot change the size of the scan pattern, but you can move the position of the scan cone.

**▶ You must use TWS mode to fire multiple AIM-120 missiles simultaneously at multiple targets.**




TWS Mode with PDT and SDT

Unlike RWS, designating a target does not switch the radar to STT. Instead, you may designate up to eight separate targets simultaneously. The first target, the Primary Designated Target (PDT) is indicated with the usual "Lock On" symbol. Up to seven more targets may be designated, called Secondary Designated Targets (SDTs), which are marked with hollow rectangles. The number above the rectangle indicates the target's altitude. The number to the right of the box shows the target's sequence number. Designating the PDT or any SDT a second time switches the radar to STT mode.

When firing multiple AIM-120 missiles, the first missile tracks the PDT. Subsequent missiles engage the SDTs in numerical sequence. That is, the second AIM-120 missile engages SDT number 1, the next missile engages SDT number 2, etc. The VDT shows contact information and missile flyout data for the PDT just like STT mode.

**▶You cannot fire AIM-7 missiles when using TWS mode. You must designate the PDT or an SDT a second time and switch the radar to STT mode.**

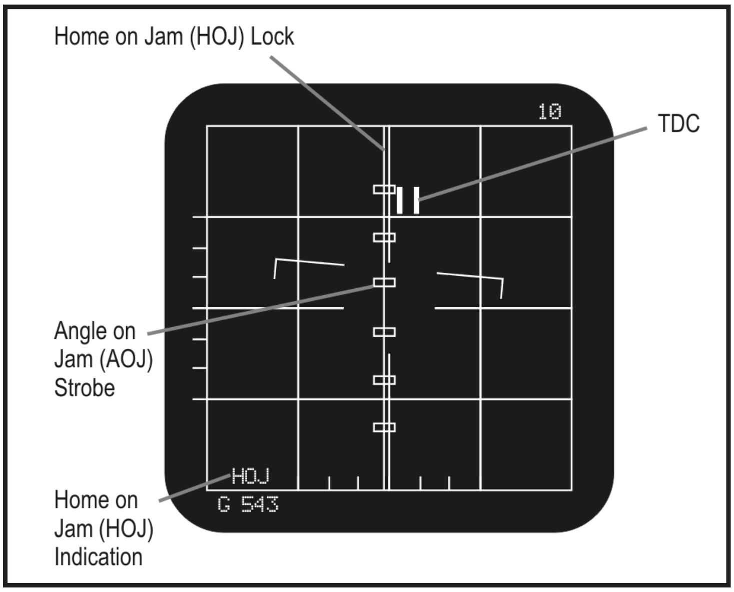
Use TWS mode with caution. The radar cannot actually track multiple targets while scanning a large volume of airspace. Instead, the radar scans each target, predicts where the target will move to, searches a wider pattern, and then returns to scan the predicted position of each target. As long as the target flies a relatively consistent course, this system works fine; however, if the contact makes a sudden, aggressive course change, the radar will continue to show the predicted course until it completes enough of the scan cycle to realize it has lost contact with the target. The target may move a considerable distance unseen while the VSD continues to display the erroneous position.

TWS is a powerful mode and necessary in order to fire multiple AIM-120 missiles at multiple targets. However, keep in mind its limitations and use it in conjunction with RWS and TWS modes.

## 4.104 Home On Jam (HOJ) Mode

If the radar detects a jamming signal, it displays a series of hollow rectangles along the bearing to the jammer on the VSD. If using AIM-7 or AIM-120 missiles, you may select and designate one of the Angle Of Jam (AOJ) rectangles. A vertical line appears through the AOJ markers and the VSD will display "HOJ" along the upper edge.  Any AIM-7 or AIM-120 missiles will fly down the bearing of the jammer, attempting to locate the source.

**▶The AOJ markers only indicate the bearing to the jammer. It does not indicate the target's speed, altitude, heading, or range.**




As you close on the jammer, eventually the reflections from your radar will be more powerful than the signals from the enemy's jammer. This is called burn through and indicates your radar is powerful enough to overcome the jamming. Once you reach burn-through range, the contact will appear on the VSD, replacing the AOJ marks.

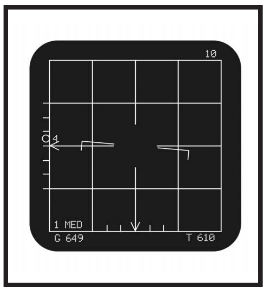
HOJ display

## 4.105 Vertical Search (VS) Auto-Acquisition Mode

Vertical Search mode searches a fixed scan pattern 7.5° wide, ranging from 5° below the aircraft to 55° above.  Range is fixed at 10 nautical miles. It automatically locks onto the target with the largest RCS within that pattern. After locking a target, the radar switches to STT mode.

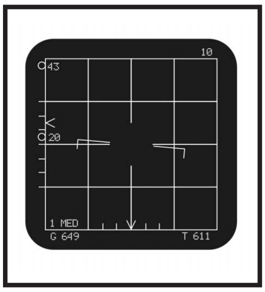
This mode is particularly useful during a close-range, turning fight when you're stuck in lag and can't quite bring your aircraft's nose onto the target. This mode scans a pattern along your lift vector, helping you acquire targets up to 55° off-boresight.

The VSD shows no useful targeting information in this mode. Refer to the Vertical Search HUD mode for additional information.




VS Auto -Acquisition Mode

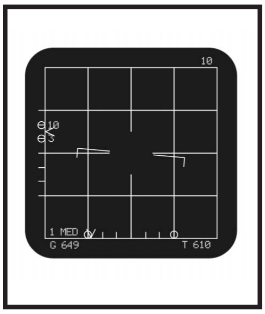
### 4.106 Boresight (BORE) Auto-Acquisition Mode




BORE Auto- Acquisition Mode

BORE mode works nearly identically to VS mode, but utilizes a smaller scan pattern aligned along the aircraft's longitudinal axis. The pattern is only 2° wide and 2 bars tall. As with VS mode, the HUD displays the significant targeting information, not the VSD. The radar locks the target with the greatest RCS within the BORE pattern and switches to STT mode.

### 4.107 Gun Auto-Acquisition Mode




Guns Auto-Acquisition Mode

Gun mode is used in close-range dogfights. Gun mode engages the cannon and selects a fixed scan pattern, 60° wide and 20° tall. The range is set to 10 nautical miles. As with VS and BORE modes, the HUD shows the relevant information, not the VSD. The radar locks the target within the pattern with the greatest RCS and switches to STT mode.

### 4.108 FLOOD Mode

FLOOD mode is a close-range, visual dogfight mode used in conjunction with AIM-7 missiles. The radar emits energy in a continuous, 16° wide, 40° tall pattern. The azimuth and elevation indicators appear, as described for RWS mode, but the antenna position carets do not move. The range indicator is fixed at 10 nautical miles. The word FLOOD appears above the VSD.

**►In FLOOD mode, all useful targeting information appears on the HUD, not the VSD.**

This mode does not display contacts, nor allow lock on. It "floods" the vicinity with radar waves. Any AIM-7 missile launched in FLOOD mode will track the target with the greatest RCS within the flood pattern. If the target moves outside of the HUD's reference circle for more than 2 seconds, the missile loses lock and goes ballistic.

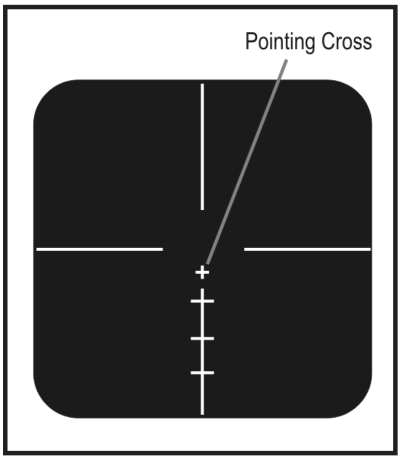
## 4.2. A-10A Maverick Seekers

The A-10A carries no radar or detection system other than the seeker heads in the AGM-65 Maverick missiles. The A-10A carries two versions of the Maverick, the television-guided AGM-65B and the Imaging Infrared (IIR) guided AGM-65K.

The AGM-65K and AGM-65D use the same procedure to attack a target. The first step is to designate the point on the ground near which your desired target is located. Press the TAB key to stabilize the Mavericks seeker on this point in pitch and yaw. Once stabilized, you can move the center of the pointing cross above your desired target. Once the target is in range, the seeker will automatically lock on to the target and follow it. You can launch the missile at this time.

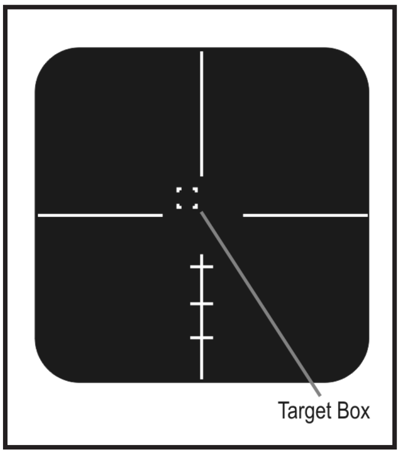
The only difference between the two versions of the Maverick is that the AGM-65K is optically guided with no magnification level and the AGM-65D is infrared-guided and has an optional 6X magnification level in addition to the default 3X.

The view from the seeker head appears on the TV monitor located on the right side of the instrument panel. The monitor shows the view with either no magnification or 4x zoom. The unmagnified view includes Narrow Field of View brackets. The brackets show the field of view visible in the monitor when zoomed to 4x magnification.




The pointing cross moves within the monitor, indicating where the missile seeker is looking relative to the aircraft centerline. For example, if the pointing cross is above and to the right of the center of the monitor, the missile is looking above and to the right of the aircraft's nose. The AGM-65 can acquire 60° off boresight, but launch constraints require the missile be within +/- 30° off boresight.

Typical AGM-65B View




AGM-65B with Tracking Gate

# RADAR WARNING RECEIVERS

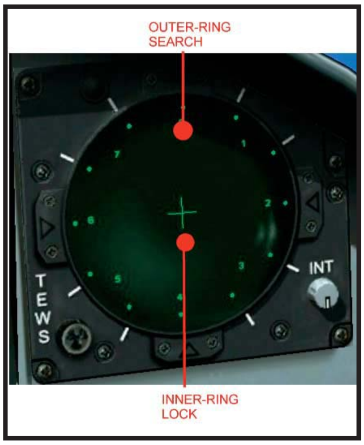
Aircraft, ships, and ground stations broadcast radar signals everywhere searching for adversaries. Naturally, modern combat aircraft carry receivers designed to detect these emissions and warn pilots. Although Eastern and Western aircraft designers take slightly different approaches to the common problem, all radar warning receivers (RWRs) share some common aspects.

First, RWR equipment is passive, meaning it emits no signals of its own. It "listens" for the emissions from other transmitters, indicating the type of transmitter, the bearing to the transmitter, and if the emitter has locked onto the aircraft. RWR gear, however, does not indicate the range to the emitter.

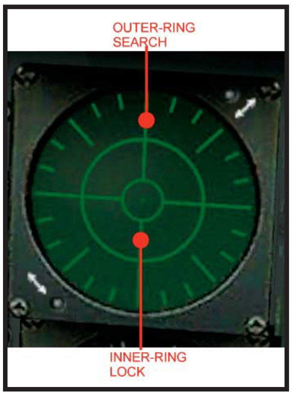
▶**RWR equipment does not indicate the range to the transmitter.**

## 5.1 U.S. Aircraft

The A-10 and F-15 radar warning receivers look slightly different, but operate virtually the same. In either aircraft, the center of the RWR represents your aircraft. The circular display represents the bearing around the plane; the top of the display indicates bearing 0 (directly ahead) while the bottom denotes bearing 180 (directly behind). The position of icons around the circle, therefore, indicates the bearing to the emitter.




F-15 Radar Warning Receiver




A-10 Radar Warning Receiver

The screen presents icons in two rings. The rings indicate the relative threat presented by the radar sources, but do not indicate the range to the emitters. The outer ring shows radars in search mode; the inner ring displays radars that have locked onto your aircraft. A tone also sounds, providing an audible alarm when radar locks onto your aircraft. Icons representing incoming radar-guided missiles will flash.

In the A-10, search and launch warnings are also indicated on the warning panel.

Radar emitters are abundant on the modern battlefield. The RWR equipment can quickly become confusing, distracting, and even overwhelming as it displays the wide variety of contacts it detects. Consequently, the RWR supports three "declutter" levels:

- **Show All:** Shows all detected radar sources.
- **Show Only Lock:** Shows only radars locked onto your aircraft.
- **Show Only Launch:** Shows only radar-guided missiles tracking your aircraft.

Each icon on the RWR display consists of two components: the radar category and the emitter type. Radars come in five general categories:


- **Early Warning Radars:** The EW icon appears on the screen indicating the bearing to the radar emitter. The scope displays EW regardless of the emitter type (1L13 or 55G6 Russian EWR stations).


- **Airborne Radars:** All airborne radars carry the ^ character above the emitter type, including AWACS and fighter radars.


- **Ground-Based Radars:** Icons for all ground-based radars, including SAM and AAA sites, appear within a box.


- **Ship-Based Radars:** Radar emitters mounted on ships appear with a bracket beneath the emitter type.


- **Active Missiles:** Icons for radar-guided missiles with onboard emitters appear within a diamond.

Symbols coupled with the radar category indicate the platform carrying the radar system. The following tables indicate symbols used for airborne, naval, land-based, and missile guidance radars.

**Airborne Radar Symbology**

| Aircraft | RWR Icon |
|---|---|
| MiG-23ML | 23 |
| MiG-29 | 29 |
| MiG-29K | 29 |
| MiG-31 | 31 |
| Su-27 | 27 |
| Su-30 | 30 |
| Su-33 | 33 |
| F-4E | F4 |
| F-14A | 14 |
| F-15C | 15 |
| F-16C | 16 |
| F/A-18C | 18 |
| A-50 | 50 |
| E-2C | E2 |
| E-3A | E3 |

**Active Radar-Guided Missiles**

| Missile | RWR Icon |
|---|---|
| R-33 (AA-9) | 9 |
| R-77 (AA-12) | 12 |
| AIM-54 | 54 |
| AIM-120 | AM |

**Ship-Based Radars**

| Ship Class | Radar System | RWR Icon |
|---|---|---|
| Azov (Kara) | SA-6 | 6 |
| Albatross (Grisha-5) | SA-8 | 8 |
| Grozny (Kynda) | SA-3 | 3 |
| Kuznetsov | SA-15 | 15 |
| Kuznetsov | 2S6 | S6 |
| Vinson | Sea Sparrow | SS |
| Moscow (Slava) | SA-10 | 10 |
| Moscow (Slava) | SA-8 | 8 |
| Nanuchka | SA-8 | 8 |
| Neustrashimy | SA-15 | 15 |
| Neustrashimy | 2S6 | S6 |
| Oliver H. Perry | Standard Missile | SM |
| Orel (Krivak-3) | SA-8 | 8 |
| Rezky (Krivak-2) | SA-8 | 8 |
| Skory (Kashin) | SA-3 | 3 |
| Spruance | Sea Sparrow | SS |
| Ticonderoga | Standard Missile | SM |

**Ground-Based Radars**

| Radar | NATO Codename | RWR Icon |
|---|---|---|
| S-300PS 40B6M tr | SA-10 | 10 |
| S-300PS 40B6MD sr | SA-10 Clam Shell | CS |
| S-300PS 5H63C tr | SA-10 | 10 |
| S-300PS 64H6E sr | SA-10 Big Bird | BB |
| S-300V 9532 tr | SA-12 | 12 |
| S-300V 9S15MT sr | SA-12 Bill Board | BD |
| S-300V 9A82 in | SA-12 | 12 |
| S-300V 9A83in | SA-12 | 12 |
| Buk 9S18M1 sr | SA-11 Snow Drift | SD |
| Buk 9A310M1 in | SA-11 | 11 |
| Kub 1S91 | SA-6 | 6 |
| Osa 9A22 | SA-8 | 8 |
| Strela-10 9A33 | SA-13 | 13 |
| Dog Ear Radar | Dog Ear | DE |
| Tor 9A331 | SA-15 | 15 |
| Tunguska | 2S6 | S6 |
| Shilka ZSU-23-4 | ZSU-34-4 | 23 |
| Roland ADS | Roland | RO |
| Roland Radar | Giraffe | GR |
| Patriot str | Patriot | P |
| Gepard | Gepard | GP |
| Hawk sr | I-HAWK PAR | HA |
| Hawk tr | I-HAWK HPI | HA |
| Vulcan | M-163 | VU |
| Zu-23 | Zu-23 | AA |

# 5.2 Russian Aircraft

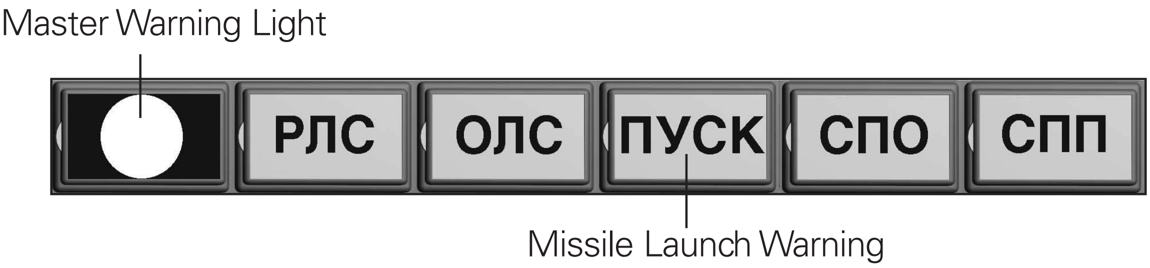
## Emergency Procedures

Onboard warning systems call your attention to battle damage, system malfunctions, enemy threats, or other dangerous situations. Correct interpretation of warning signals may save your aircraft, or at least save your life by providing sufficient time to eject.

## Master Warning System

The Master Warning System (MSW) is designed to attract your attention to a specific failure. A Master Warning Light will flash and an alarm tone will draw your attention to the instrument panel.

The MWS indicates that one of the following has occurred:




- **Impact with the ground is imminent** – Accompanied by an "X" symbol on the HUD, your current flight path will result in a collision. The light flashes at 1 Hz and emits an audible alarm. Pull up immediately.
- **Low fuel** – The MWS light flashes at 1 Hz and is accompanied by an alarm beep for 10 seconds. The red NJGKBDJ light on the fuel gauge also illuminates. Land as soon as possible.
- **Landing gear is still deployed at a high airspeed** – The warning light flashes at 1Hz and is accompanied by a warning beep. Both alarms cease when you retract the landing gear.
- **Some onboard equipment has failed or taken battle damage** – Check the instrument panel for individual warnings or failure indicators, such as a failed engine, failed hydraulic system, or malfunctioning radar. See later sections for more information on handling specific failures.
- **Your aircraft is being painted by enemy radar** – The MWS flashes at 5 Hz when the RWS detects enemy emissions. Flashing changes to 1 Hz when a lock-on has been detected. Check the threat warning display in the lower right corner of the instrument panel. Take evasive action as appropriate.
- **The Missile Launch Warning System has detected an inbound missile** – The MWS light is accompanied by the Missile Launch Warning light. Take evasive action immediately.

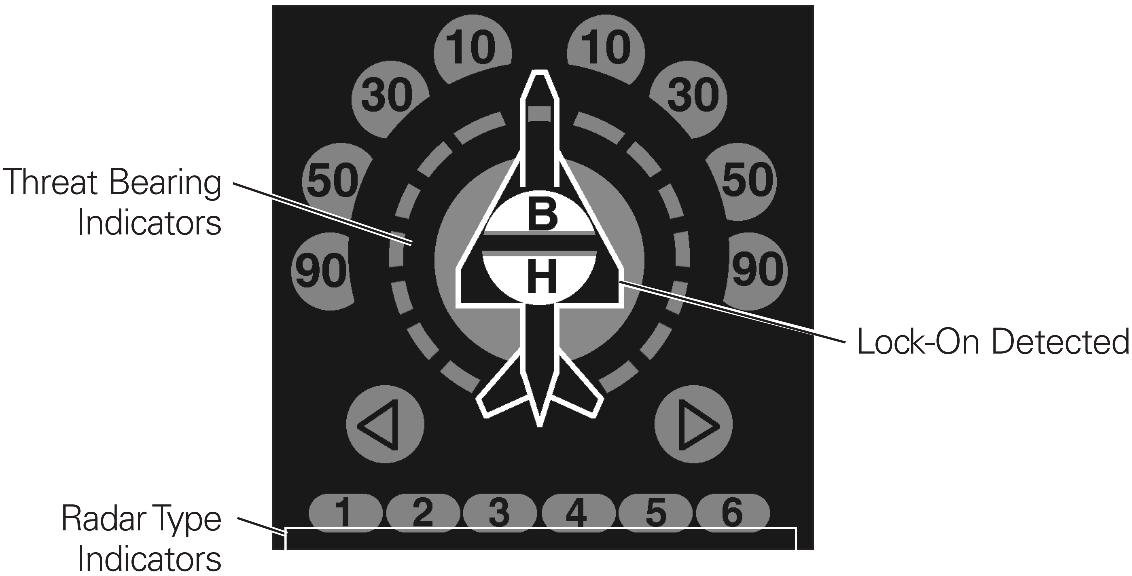
To reset the MWS, press the Shift + M key.

## Radar Warning System

The SPO-15 "Beryoza" Radar Warning System (RWS) detects enemy radar signals and operates like any radar detector used in automobiles to locate police radar. Thanks to a more complicated antenna system (fitted in the tailcone) and more processing power, the RWS not only detects radar, but also indicates the bearing to the transmitter and the type of radar detected. A totally passive system, it merely listens for other's emissions. This system is used in a variety of Russian aircraft including the MiG-29 Fulcrum , MiG-31 Foxhound, and Mi24P Hind.

The ten lights surrounding the MiG-21 picture illuminate to indicate the bearing to the transmitter. A flashing light indicates your aircraft is being painted occasionally by the emitter. A solid light indicates that a transmitter is tracking your aircraft. A red light surrounding the silhouette indicates a lock onto your aircraft. The six lights along the bottom of the RWS correspond, from left to right, to five categories of radar signals:

- Airborne radar
- Short-ranged SAM
- Medium-ranged SAM
- Long-ranged SAM
- Early warning radar
- AWACS




All Russian aircraft are equipped with an Identification Friend or Foe (IFF) system, allowing the RWS to distinguish between friendly and hostile radar sources. This system also replies to friendly emitters, alerting them that you're not a hostile target.

## *Missile Launch Warning System*

The infrared MLWS detects the hot emissions produced by incoming missiles. A totally passive system, it watches for the type of heat produced by solid-propellant rocket motors. Its effective range varies depending on the intensity of the heat emission, but can generally spot inbound missiles up to 15 km away.

When the MLWS detects an inbound missile, the GECR symbol (meaning "launch" in Russian) illuminates and produces a warning beep at 2 Hz for five seconds. The MLS light also illuminates. After five seconds the audio alarm silences, but the warning light remains on until the system loses contact with the missile.

**▶ When the MLWS illuminates, take evasive action immediately!**

The voice messaging system also provides audible cues indicating where the missile is coming from. The system will announce "Missile at…" followed by a clock position such as "12 high" or "6 low."

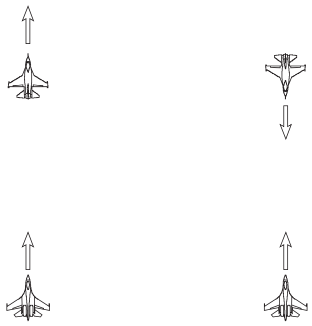
# AIR-TO-AIR MISSILES

Like aircraft, missiles must obey the laws of physics and have very specific flight envelopes. When fired within the appropriate parameters, missiles have a deadly performance advantage over aircraft. When fired in marginal situations, however, the missile's chances of success go down dramatically.

## Kinematic Range Against Non-Maneuvering Targets

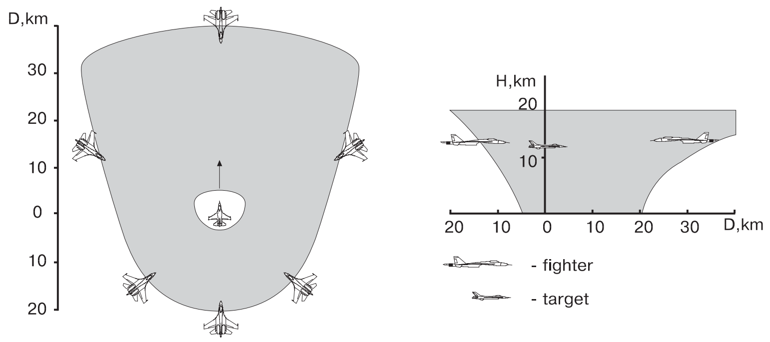
Like aircraft, a missile's biggest problem is thrust. Missiles have a very limited amount of space for onboard fuel. Consequently, a missile's engine burns for a very short time (just a few seconds in some cases) and quickly accelerates the missile to maximum speed. The motor then burns out and the missile relies on its rapidly decaying momentum to reach the target. As with aircraft, the missile's turn performance is dependent upon how many g's it can pull. The slower the missile is, the less g's it can pull. The maximum range at which the missile is effective against a non-maneuvering target is called its kinematic range. As we'll see later, however, "range" is a very elusive topic.

Target aspect angle has a large impact on the missile's effective range. As shown in the figure below, a target heading directly at the missile covers part of the range. The shooter can fire the missile earlier since the target flies toward the missile, shortening the missile's time of flight. Conversely, a tail aspect greatly reduces missile range since the target is running away from the missile. Suppose the missile is fired at a target 10 km away. It takes the missile several seconds to travel that distance. By the time the missile has flown 10 km, the target may have moved another one or two kilometers further away. Missiles are substantially faster than aircraft, but run out of fuel much faster as well.



Effects of Head and Tail Aspect Angles on Missile Kinematic Range

The left-hand illustration in the figure on the facing page shows a typical envelope for a missile fired at a non-maneuvering target (in the center of the diagram). The gray zone represents the ranges from which the missile may be fired based on aspect angle. Notice that when fired head-on, the range is significantly longer than when fired from behind. The white area around, the target defines the minimum range requirements for the missile. Since directly hitting the target is unlikely, most missile warheads are designed to emit some form of shrapnel in order to damage nearby aircraft. To prevent the launching aircraft from being inadvertently damaged by the missile explosion, the missile does not arm until it has flown a safe distance from the shooter. Also, the missile seeker or guidance system may require some amount of time to engage the target. The distance the missile must fly is known as the minimum range.




Typical Missile Envelope Against a Co-altitude, Non-maneuvering Target

Notice the right-hand illustration in the figure above. This shows the second major factor in missile range: altitude. Generally speaking, a missile's kinematic range doubles for each 6,100 m (20,000 ft) that altitude is increased. For example, if the missile's kinematic range is 20 km at sea level, it will double to approximately 40 km when fired at a co-altitude target 6,100 m higher. At 12,200 m (approximately 40,000 ft), missile range would increase to 80 km. When fired at a higher or lower target, the missile's range is generally associated with the median altitude between the shooter and the target (assuming the missile can climb high enough when fired at a higher altitude target).

Finally, the speed of the launching aircraft greatly impacts missile kinematic range. The slower the launcher is moving, the longer the missile will take to reach maximum speed. More of its limited motor burn will be spent accelerating to cruise speed. If the missile is launched at a higher speed, it will reach cruise speed and altitude faster, saving more of the motor burn for the "cruise" portion of the flight. Likewise, the speed of the target impacts the missile range as well. The faster the target is moving, the more distance it will cover during the missile's time of flight. In a tail-chase scenario, the target may escape the missile's maximum range. In a head-on scenario, the target may close inside the missile's minimum range!

## Maneuvering Targets and Missile Evasion

Unfortunately, target aircraft rarely cooperate with your plans and often attempt to evade your missiles. So far, we have not discussed how target maneuvering affects missile performance. When fired at a maneuvering target, the missile will follow a curved trajectory to the target. This increases drag, bleeds speed, and reduces the missile's effective range.

The target may attempt to "drag" the missile; in this case the target executes a high-g turn until it facing directly away from the missile, then unloads to 1 g and accelerates directly away from the incoming missile. In this case, the target is attempting to place the missile in the shorter "tail aspect" portion of its flight envelope. Success depends primarily on how quickly the target can turn (a light fighter may execute an 8 g or 9 g turn; a heavily laden attack aircraft may be limited to 5 g or 6 g) and how quickly it can accelerate after bleeding speed away in that turn. Modern, more-capable missiles may have a no-escape zone; that is, at a given range (say 10 km), no aircraft in the world can turn fast enough and accelerate fast enough to escape. That same missile, though, may be unable to catch an aircraft performing a 6.5 g drag turn 25 km away.

The target may also attempt to "beam" the missile by turning toward the missile to place the inbound missile at either the 3 o'clock or 9 o'clock position, then maintaining a sufficient turn to keep the missile there. This forces the missile to execute a continuous turn, bleeding speed and energy all the while. The target may also turn away to place the missile at the beam position as well. In any event, the target is trying to make the missile expend as much energy as possible, which shortens its range and its maneuverability.

### Conclusion

From this we see that "missile range" is a very complex topic. Merely knowing that a missile has a 30 km range doesn't do much good… When fired from what altitude? When the target is at what altitude? Against what aspect angle? At what airspeed? Overall, we can draw two main conclusions:

1. The closer you are to the target when you shoot, the better the chances that your missile will hit the target. Missiles fired at or near their maximum range (for the given circumstances) are not very likely to hit.
2. Launching from higher airspeed and altitudes significantly increases the missile's effective range.

## *Missile Guidance*

The missile's guidance systems provide input to the missile's control system, which in turn maneuvers 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 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 or active.

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 use infrared or radar.

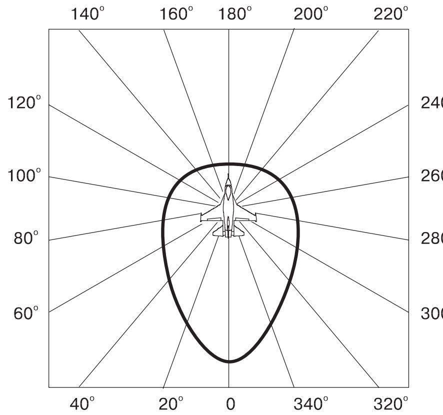
## Passive Homing

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.

**▶Passive seekers have an inherent advantage in their maximum range because their received power is inversely proportional to the square of the target range. The maximum range of active and semi-active systems varies inversely with the fourth power of the transmitter strength.**

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.



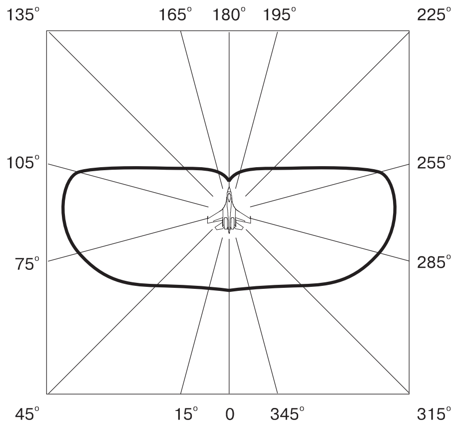

IR Radiation Intensity

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 vapor, making heat seekers all but useless in clouds or rain. Discrimination between the target and background radiation generated by the sun or 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 emissions 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; i.e., its radar cross-section (RCS). This ability significantly depends on the aspect angle of the target. Besides aspect angle, the reflection of radio waves depends on the size, shape, and details of construction of the target. The figure below shows a typical diagram of reflected signal intensity:




Radar Cross-section Illustrated

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 maneuvering 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

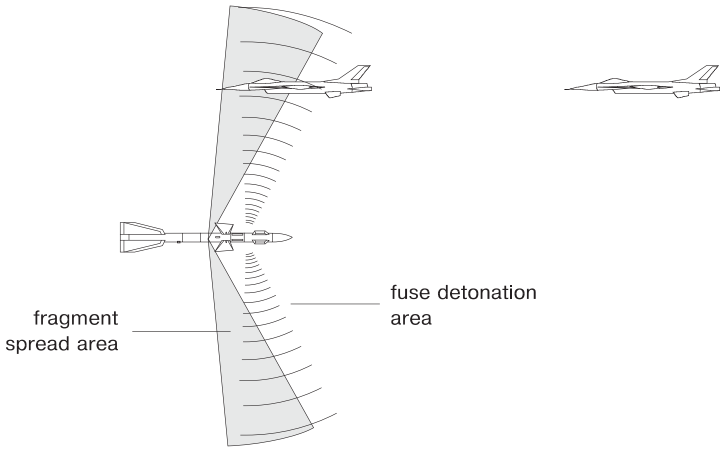
The warheads used in AAMs are typically blast-fragmentation, creating a cloud of incendiary/explosive pellets or an expanding metal rod. Blast fragmentation warheads cause damage through the combined effects of the explosive shock wave and high-velocity fragments (usually pieces of the warhead casing). 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 maneuverable it is.

The purpose of a missile fuse system is to cause 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 preset 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 maneuvering 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 Patterns

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

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

## 6.1. NATO Air-to-Air Weapons

### 6.101 AIM-120 AMRAAM

The AIM-120 is the most effective, versatile air-to-air missile in service with Western forces. It has the greatest range, widest performance envelope, and the most capable guidance mechanism of any radar-guided missile in the West.

The launching F-15 must obtain a radar lock in STT or TWS radar modes. The radar sets a “fly out” point for the missile. When launched, the missile uses inertial guidance to fly to that point, where it activates its onboard radar and searches for the target. As long as the F-15 maintains a radar lock, it updates the “fly out” point to ensure the target is visible when the missile goes active. The radar relays the updated coordinates to the missile via a secure data link.

If the radar loses lock, it stops transmitting guidance instructions to the missile. In this case, the missile continues to the last coordinates it received and activates the onboard radar. It will engage the target with the largest radar cross-section it finds within its search pattern.

See the "HUD" chapter for details on targeting and firing the AIM-120.

**AIM-120**

**Type:** Medium-range, radar-guided, air-to-air missile

**Weight, kg:** 157

**Length, m:** 3.65

**Body Diameter, m:** 0.178

**TNT Equivalent, kg:** 22

**Guidance:** Command, inertial, and active radar

**G Limit:** 22

**Maximum Mach Number:** 3

**Range, km:** 50

**Aircraft Types**

1. F-15C

**Target Acquisition Modes**

1. STT mode with locked target
2. TWS mode with one or more designated targets

## 6.102 AIM-7 Sparrow

The Semi-Active Radar Homing (SARH) AIM-7 Sparrow served as NATO's primary Beyond Visual Range (BVR) missile for over two decades. The missile performed rather poorly in the skies over Vietnam, but improved versions accounted for the majority of air-to-air kills scored by the U.S.A. during the 1991 Gulf War.

The Sparrow does not carry a radar emitter. The launching aircraft must maintain a radar lock on the target, allowing the missile to home in on the radar waves reflected by the target. If the launching platform loses lock, the missile can no longer see the target and goes ballistic.

Alternatively, in dogfight situations, the F-15's FLOOD radar mode paints a broad radar pattern. Although it does not lock the target, AIM-7 missiles can still home in on the radar energy reflected by targets within the scan pattern. In FLOOD mode, the AIM-7 will track the target with the greatest radar cross-section up to 10 knots away.

See Chapter 3 for details on targeting and firing the AIM-7.

**AIM-7**

**Type:** Medium-range, radar-guided, air-to-air missile

**Weight, kg:** 230

**Length, m:** 3.66

**Body Diameter, m:** 0.203

**TNT Equivalent, kg:** 39

**Guidance:** Semi-active radar

**G Limit:** 20

**Maximum Mach Number:** 3

**Range, km:** 45

**Aircraft Types**

1. F-15C

**Target Acquisition Modes**

1. STT mode with a locked target
2. FLOOD mode with targets within 10 nm

### 6.103 AIM-9 Sidewinder

The heat-seeking AIM-9 Sidewinder has been NATO's workhorse missile for decades, but has begun to show its age. Although a potent all-aspect missile, it lacks the high off-boresight capability and maneuverability of the Russian R-73 (AA-11 Archer).

The AIM-9 locks targets through two methods. First, an F-15C can fire AIM-9 missiles at radar-locked targets in STT mode. Secondly, either an A-10A or an F-15C can use the missile's onboard seeker to track targets prior to firing the missile. In boresight mode, the missile seeker monitors a narrow area directly ahead. Uncaging the seeker lets the missile seeker head move in a search pattern, giving the missile a wider view of the airspace ahead. In either case, when the missile detects a heat source, it emits a tone. The tone increases in pitch as the missile gains a stronger track.

Heat-seeking missiles do not emit any signals and are therefore very difficult to detect. Unlike radar-guided missiles, enemy aircraft generally receive no warning of approaching heat-seeking missiles.

See Chapter 3 for details on targeting and firing the AIM-9.

**AIM-9**

**Type:** Short-range, infrared, air-to-air missile

**Weight, kg:** 85.5

**Length, m:** 2.87

**Body Diameter, m:** 0.127

**TNT Equivalent, kg:** 10

**Guidance:** Infrared

**G Limit:** 22

**Maximum Mach Number:** 2.5

**Range, km:** 8

**Aircraft Types**

1. A-10A
2. F-15C

**Target Acquisition Modes**

1. F-15C STT mode with a locked target
2. F-15C / A-10A seeker boresight (no radar)
3. F-15C / A-10A seeker uncaged (no radar)

## 6.2. Russian Air-to-Air Weapons

### The GSh-301 Cannon

The gun is the most basic of air combat weapons. Although many believed the advent of air-to-air guided missiles would make the gun obsolete, repeated experience has shown that the gun remains an integral part of an aircraft's weapons package. The Flanker carries 150 rounds of 30mm ammunition capable of inflicting serious damage on an enemy aircraft. Activate the cannon mode by pressing the C key from any air-to-air mode or while in air-to-ground mode.

### Using Radar or Electro-Optical System (EOS) Targeting

Fortunately, the radar and EOS simplify the task of aerial gunnery by accurately measuring the range to the target and providing helpful cues on the HUD. Locking a target in Close Air Combat or Helmet Mounted Sight modes greatly improves the chances of hitting the target.

Once the target has been locked, extra cues appear on the HUD. The left side of the HUD shows the "Autotrack" cue (indicating the system is operational and tracking a target) along with a vertical range bar. The range bar provides three types of information at once:

1. **Range to target** – The arrow symbol along the right side of the range bar indicates how far away the target is. The marks along the left side of the bar help estimate the distance.
2. **Effective cannon range** – The marks along the right side of the bar indicate the cannon's maximum and minimum firing ranges.
3. **Aspect angle** - The pointed arrow affixed to the bottom of the range bar shows the target's heading relative to yours. If the arrow points straight up, you're directly behind the target. If the arrow points straight down, the target is heading directly at you.

The Autotrack HUD Symbology (Range > 1400 m)

As usual when locking a target, the target's airspeed and altitude are displayed above your own. The number of cannon rounds remaining is displayed in the lower right corner of the HUD. The aiming reticle is superimposed over the target as long as you maintain the lock.

**►In general, steer your aircraft to keep the aiming reticle near the center of the HUD; this prevents the target from breaking the lock with a sudden maneuver.**

As you close inside 1,400 m, the symbology changes. The range bar disappears and aiming crosshairs, also called "pippers," appear. The circle around the aiming crosshairs now represents the range to the target; the arc of the circle recedes counterclockwise as you get closer. The smaller the arc, the closer you are to the target. A full circle indicates the target is 1400 meters away.

To shoot the target, maneuver the pipper over the aiming reticle. When the computer calculates that you're in range, the Shoot Cue will appear. If you approach the target too closely, the HUD may show the Reject Cue OTB.

If the target manages to break the tracking lock, the HUD switches to the standard gun funnel mode. To re-establish the lock, disable the cannon by pressing C and repeat the target lock sequence using the radar.

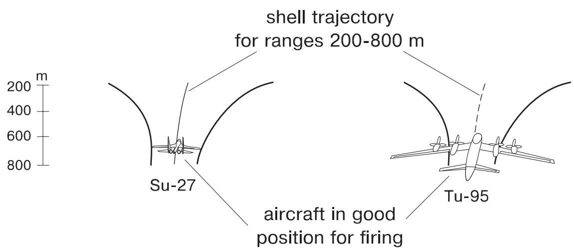
## Using the Cannon Funnel

In the event that the radar and EOS are unavailable or you are unable to achieve a lock, you can use the funnel display to manually aim the guns. The funnel appears whenever you enable the cannon (by pressing C) without having first acquired a lock. The funnel is designed to indicate the required amount of lead angle when firing at a fighter-sized target 200 m to 800 m away.

The funnel consists of two curved lines. The distance between the two lines represents a width of 15 m (the approximate wingspan of many fighter-sized targets) at varying ranges from 200 m (top of the funnel) to 800 m (bottom of the funnel). To use the funnel, bank your aircraft until the horizontal line in the middle is parallel to the target's wings (indicating you are in the same plane of maneuver as the target). Pull lead until the wingtips of the target just touch the two outer edges of the funnel. The further away the target is, the smaller its wingspan appears, so the further down the funnel you place it, thereby increasing the amount of lead you're pulling. Rounds fired now will impact the target.

The Gunnery Funnel

What happens if the target's wingspan is greater than (or less than) 15 m? The funnel specifically represents a wingspan of 15 m; against larger or smaller targets you'll have to estimate the difference. For example, a large target like a Tu-95 has a wingspan of roughly 50 m and will overlap the funnel. This figure compares an Su-27 and a Tu-95 700 m away:




Comparing Target Wingspans with the Targeting Funnel

The following table shows the wingspans (minimum and maximum for variable-geometry aircraft) that you're likely to encounter. When engaging a target smaller or larger than 15 m, remember to adjust the funnel accordingly. If the target is smaller, don't pull as much lead. If the target is larger, pull more lead than indicated by the funnel.

| 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 |

## Long-Range Missiles

### R-33E / AA-9 Amos

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 / AA-7 Apex

The Vympel R-23 (AA-7 Apex) medium-range missile comes in two modifications with different seeker types. The R-23R (AA-7A) has a semi-active radar seeker while the R-23T (AA-7B) has an IR seeker. Both missiles have a maximum range of about 25–35 km. An older missile, the R-23 is often replaced by the more powerful and intelligent R-27 Alamo.

### R-27 / AA-10 Alamo

AA-10 Alamo (see also AA-10; R-27; the Vympel R-27) 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 in place of the R-23 Apex used by the MiG-23. The R-27 is effective against highly maneuverable 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 g's.

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 recognizable 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 | Russian | Guidance | Maximum Range at High Altitude/Low Altitude, km |
|---|---|---|---|
| R-27R | P-27 | Inertial radio-corrected guidance and semi-active radar terminal homing | 80/10 |
| R-27T | P-27 | All-aspect passive infrared homing | 72/10 |
| R-27RE | P-27Э | The same as in R-27R | 170/30 |
| R-27TE | P-27Э | The same as in R-27T | 120/15 |
| R-27EM | P-27ИМ | Inertial radio-corrected guidance and semi-active radar terminal homing (able to destroy cruise missiles at a height of 3 m above water surface) | 120/20 |
| R-27AE | P-27АИ | Inertial radio-corrected guidance and active radar terminal homing | 120/20 |

### R-77 / AA-12 Adder

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 R-77 can be effectively used against highly maneuverable 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 has a maximum speed at high altitude of Mach 4.0.

## *Close Air Combat Missiles*

### R-60 / AA-8 Aphid

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 / AA-11 Archer

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 maneuverable 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 g's.

The R-73 employs aerodynamic control combined with vectored thrust. Tremendous maneuverability (up to 12 g's) 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 meters 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 parentheses.

| Type | Russian | USA/NATO | Carrier (#) | Weight, kg | Seeker | Range, km (Maximum range at high altitude) |
|---|---|---|---|---|---|---|
| R-23R | P-23P | AA-7A/Apex | MiG-23 (2) | 223 | SARH | 35/25 |
| R-23T | P-23T | AA-7B/ Apex | MiG-23 (2) | 217 | IR | 35/25 |
| R-27R | P-27P | AA-10A/Alamo-A | MiG-29 (4),<br>Su-27 (6),<br>Su-33 | 253 | SARH | 80 |
| R-27T | P-27T | AA-10B/Alamo-B | MiG-29 (4),<br>Su-27 (6), s<br>Su-33 | 254 | IR | 72 |
| R-27RE | P-27HЭ | AA-10C/Alamo-C | MiG-29 (4),<br>Su-27 (6),<br>Su-33 | 350 | SARH | 170 |
| R-27TE | P-27NЭ | AA-10D/Alamo-D | MiG-29 (4),<br>Su-27 (6),<br>Su-33 | 343 | IR | 120 |
| R-33A | P-33F | AA-9/Amos | MiG-31 (6) | 490 | SARH | 160 |
| R-60 | P-60 | AA-8/Aphid | Su-24 (2),<br>Su-25 (2),<br>MiG-23 (4),<br>MiG-27 (2) | 45 | IR | 10 |
| R-73 | P-73 | AA-11/Archer | MiG-29 (6),<br>MiG-31 (4),<br>Su-24 (2),<br>Su-25 (2),<br>Su-27 (10),<br>Su-33 | 110 | IR | 30 |
| R-77 | P-77 | AA-12/Adder | MiG-29 (6),<br>MiG-31 (4),<br>Su-25 (2),<br>Su-27 (10),<br>Su-33 | 175 | Radio command +ARH | 90 |

# AIR-TO-GROUND WEAPONS

Air-to-ground weapons come in two categories: guided and unguided. Guided weapons include air-to-ground missiles and laser-guided bombs. Unguided weapons include rockets and free-fall bombs.

Free-fall bombs, also called iron bombs, are the mainstay of air-to-ground weapons. Although modern guided weapons are substantially more accurate, such "smart" weapons are also substantially more expensive. Iron bombs, therefore, have remained in widespread service around the world for seven decades.

Iron bombs are not particularly accurate. They simply fall to the ground with no ability to maneuver or steer. The launching aircraft must fly a stable, consistent flight path when releasing the weapon. Banking the wings or making sudden pitch changes when releasing the weapon slings it off course. Wind can also push the bomb off course. Therefore, iron bombs should not be used in situations requiring high precision or minimal collateral damage.

**►Sudden flight path changes when releasing iron bombs greatly reduces accuracy.**

The effective range of an iron bomb depends primarily on two factors: the speed and the altitude of the releasing aircraft. Increasing speed and increasing altitude "throws" the bomb further. The following table illustrates the effect of airspeed and altitude on the effective range of a typical 500 lb iron bomb when released from straight-and-level flight.

| Altitude (AGL) | Airspeed (kts) | Bomb Range (ft) |
|---|---|---|
| 500 | 240 | 2100 |
| 500 | 400 | 3600 |
| 1000 | 240 | 3100 |
| 1000 | 400 | 5100 |
| 1500 | 240 | 3800 |
| 1500 | 400 | 6300 |
| 2000 | 240 | 4400 |
| 2000 | 400 | 7200 |
| 4000 | 240 | 6200 |
| 4000 | 400 | 10200 |

Iron bombs come in many sizes and shapes, ranging from 500 lbs to 2,000 lbs. Most "general purpose" bombs carry a single explosive warhead, while Cluster Bomb Units (CBUs) contain a canister of "bomblets" which are dispersed over a wide area.

**►Iron bomb range is primarily determined by the speed and altitude of**

**▶Generally, fire rockets in volleys to saturate the target.**

Guided missiles and bombs are the most effective, but also the most expensive. Laser-guided, IR-guided, and television-guided weapons have amazing precision, able to strike a single tank within a column or strike a specific section of a building. Employment procedures and operational constraints vary depending upon the weapon type, but higher altitudes and faster airspeeds generally increase their effective range.

## 7.1. NATO Air-to-Ground Weapons

### 7.101 LAU-10 and LAU-61 Rockets

Rockets, because of their inherent inaccuracy and relatively limited firepower, see limited use in the U.S.A.F. Rockets have no guidance mechanisms, requiring visually aiming. Rockets are notoriously inaccurate; the slightest variation in flight path while firing rockets can substantially alter their flight path and reduce their accuracy. Wind is especially problematic. Gusting winds can push the rockets off course, and rockets have a propensity to "weather vane," or turn into the wind.

Rockets are only effective against "soft" targets, such as trucks, lightly armored vehicles, and troop concentrations. Generally, rockets must be fired in large volleys to ensure target saturation. The LAU-10 canister carries four 5-inch rockets. The LAU-61 canister holds 19 smaller, 2.75-inch rockets.

See Chapter 3 for details on aiming rockets.

**LAU-10 (Zuni)**

**Type:** 127mm unguided rocket

**Weight, kg:** 56.3

**Length, m:** 2.93

**Body Diameter, m:** 0.127

**TNT Equivalent, kg:** 26

**Speed Km/H:** 2520

**Range, km:** 4

**LAU-61 (Hydra)**

**Type:** 70mm unguided rocket

**Weight, kg:** 6.2

**Length, m:** 1.06

**Body Diameter, m:** 0.070

**TNT Equivalent, kg:** 2.4

**Speed Km/H:** 4388

**Range, km:** 8.8

**Aircraft Types**

1. A-10A

## *7.102 Mk 82 and Mk 84 General-Purpose Bombs*

The basic Mk 80 series of Low-Drag General-Purpose (LDGP) bombs, also called "iron bombs," have been the mainstay of U.S.A.F. ground-attack aircraft for decades, and are carried by a wide variety of aircraft. The bombs are effective against a wide variety of targets, including trucks, bunkers, air defense sites, buildings, bridges, etc. The 500 lb Mk 82 and 2,000 lb Mk 84 have seen extensive action over the decades. 12,189 Mk 84 and 77,653 Mk 82 bombs were dropped during the 1991 Gulf War.

Being unguided, the pilot aims the weapon visually. With practice, a well-trained pilot can usually achieve a 400 ft Circular Error Probability (CEP), meaning half of the bombs dropped will land within 400 ft of the intended target. Although guided weapons greatly improve accuracy, they are significantly more expensive than unguided iron bombs, meaning the Mk 82 and Mk 84 are likely to remain in front-line service for many years to come.

The effective range of an iron bomb varies greatly depending upon the speed and altitude of the releasing aircraft. Flying higher and faster significantly increases the effective range.

SeeThe "Heads-Up Display Mode" chapter for details on aiming iron bombs.

**Mk-82**

**Type:** General-purpose bomb

**Weight, kg:** 241

**Length, m:** 2.21

**Body Diameter, m:** 0.273

**TNT Equivalent, kg:** 89

**Mk-84**

**Type:** General-purpose bomb

**Weight, kg:** 894

**Length, m:** 3.84

**Body Diameter, m:** 0.46

**TNT Equivalent, kg:** 428

**Aircraft Types**

1. A-10A

## *7.103 AGM-65B and AMG-65K Maverick Missiles*

The AGM-65B and AGM-65K Maverick missiles are highly accurate, very effective fire-and-forget missiles. With an effective range of about 10 nm (depending on the altitude and airspeed of the launching aircraft), the Maverick carries an 80 lb high-explosive, shaped-charge warhead and is very effective against armored vehicles. Targeting procedures are somewhat labor intensive, though, and can be difficult to employ in combat.

The Maverick is one of the A-10A's most important weapons. Of the 5,255 Mavericks fired during the 1991 Gulf War, over 4,000 were fired from Warthogs. The AGM-65 is intended for use against armored vehicles, bunkers, boats, radar vans, and small "hard targets."

The AGM-65B carries an electro-optical (television) seeker limited to daylight and good weather conditions. The AGM-65K uses an Imaging Infrared (IIR) seeker, which detects heat emitted by the target. The IIR seeker can therefore be used at night or in hazy conditions. Neither missile receives any kind of guidance information from the aircraft after launch. The pilot is free to maneuver or engage another target as soon as the missile comes off the rail.

See the "Sensors" chapter for details on using AGM-65 missiles.

**AGM-65B**

**Type:** Short-range, TV-guided, air-to-surface missile

**Weight, kg:** 210

**Length, m:** 2.49

**Body diameter, m:** 0.305

**TNT Equivalent, kg:** 57

**Guidance:** TV

**G Limit:** 16

**Maximum Mach Number:** 0.85

**Range, km:** 27

**AGM-65K**

**Type:** Medium-range, infrared, air-to-surface missile

**Weight, kg:** 220

**Length, m:** 2.49

**Body Diameter, m:** 0.305

**TNT Equivalent, kg:** 57

**Guidance:** Imaging Infrared

**G Limit:** 16

**Maximum Mach Number:** 0.85

**Range, km:** 27

**Aircraft Types**

1. A-10A

## 7.104 Mk 20 Rockeye Cluster Bomb

The Mk 20 Rockeye is an unguided, free-fall cluster bomb containing 247 armor-piercing submunitions. The Rockeye releases the bomblets in a rectangular pattern and is highly effective against tanks, vehicles, and troop concentrations. The Rockeye is not effective against hardened structures, like bunkers or bridges. Nearly 28,000 Rockeyes were dropped during the 1991 Gulf War.

Being an unguided iron bomb, the Mk 20 shares the employment constraints of other iron bombs: visual targeting reduces accuracy, and effective range is determined primarily by the speed and altitude of the releasing aircraft.

See Chapter 3 for details on aiming iron bombs.

**Rockeye (Mk20)**

**Type:** Multipurpose cluster bomb

**Weight, kg:** 222

**Length, m:** 2.34

**Body Diameter, m:** 0.335

**TNT Equivalent, kg:** 50

**Aircraft Types**

1. A-10A

### 7.105 ALQ-131

The Westinghouse ALQ-131 jamming pod began development in the early 1970's. It operates over a wide range of frequencies and utilizes a power management module to control the jammer's output power. With digital reprogrammable software, the ALQ-131 still provides effective jamming support on today's electronic battlefield.

# 7.2. Russian Air-to-Ground Weapons

## 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 stabilizers, 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.

### Free-Fall Bombs

Free-fall bombs have no guidance or control capabilities, falling along a relatively predictable path depending on the flight profile of the aircraft at the time of release.

### 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 caliber in kilograms: 250, 500, and 1500 kg, correspondingly. These bombs damage targets mainly by shock wave, and they are effective against defense facilities, industrial facilities, railway junctions, ships, and soft targets.

General-purpose bombs are the cheapest of all major air-to-ground munitions. 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 creates a cloud of small fragments and shrapnel. This weapon is effective against personnel and lightly armored vehicles. It is released at airspeeds from 500 to 1000 km/h and at altitudes from 500 to 5000 m using any delivery method.

### PB-250 Retarded Bomb

The PB-250 is a 250 kg blast-fragmentation bomb fitted with 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 blast radius before the weapon detonates.

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 armored vehicles, truck convoys, parked aircraft on airfields, etc. Delivery the weapon from low altitudes of 100-300 meters and at airspeeds of 500-1000 km/h.

### BetAB-500ShP Concrete-Penetrating Bomb

The BetAB-500ShP concrete-penetrating bomb (BetAB stands for Concrete-Piercing Aviation Bomb in Russian) is a special-purpose bomb effective against reinforced concrete bunkers and runways. As opposed to a general-purpose bomb, the BetAB has a stronger frame and a hardened nose. Given sufficient kinetic energy, the bomb penetrates through the 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.

Deliver the weapon from altitudes of 150-500 m at airspeeds from 550 to 1100 km/h.

### ZAB-500 Incendiary Bomb

The ZAB-500 is a 500 kg incendiary bomb (ZAB stands for Incendiary Aviation Bomb in Russian) used against 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 fragmentation, antitank, incendiary, concrete-piercing bomblets. Each bomblet weighs up to 25 kg.

Release of the RBK-500 bomb (RBK stands for Expendable Bomb Cassette in Russian) arms a proximity fuse, which detonates within a preset time at a preset altitude. The casing breaks apart into two halves and ejects the bomblets in a dense cloud. The bomblets 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 Cluster Bomb

Bomblets can also be dispensed from an aircraft-mounted, multipurpose nondrop pod (Russian designation KMGU stands for Unified Container of Small Loads) containing up to four compartments. The pilot can dispense submunitions from two compartments at a time or from all the compartments simultaneously. The submunitions should be dispensed in level flight at low altitudes (50–150 m) and at airspeeds of 500–900 km/h.

## 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 armor-piercing warhead.

Like air-to-ground missiles, guided bombs use TV, IR, and laser targeting techniques. As with missiles, weather and moisture degrade targeting capability.

### KAB-500KR/L TV/IR-Guided Bomb

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

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 m.

### KAB-1500L Laser-Guided Bomb

Front-line and long-range aircraft often carry the powerful KAB-1500L laser-guided bomb. It is effective against super-hardened targets, hardened fortification installations, nuclear storage bunkers, strategic command centers, etc. The KAB-1500L employs semi-active laser homing with impact accuracy of about 1–2 m. The bomb is fitted with either a penetrating warhead (capable of penetrating up to 2 m of concrete), or an explosive warhead (which blasts a crater wider than 20  m in diameter). The pilot can employ the bomb at altitudes from 500 to 5000 m 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,<br>OFAB-250,<br>PB-250 | Su-33 (12),<br>Su-24 (18),<br>Su-25 (10),<br>MiG-27 (8),<br>MiG-29 (8),<br>Tu-95 (60) | 250 | 230 | blast<br>blast-fragm.<br>blast-fragm. |
| FAB-500 | Su-33 (6),<br>Su-24 (8),<br>Su-25 (8),<br>MiG-27 (4),<br>MiG-29 (4),<br>Tu-95 (30) | 500 | 450 | blast |
| FAB-1500 | MiG-27 (2),<br>Tu-95 (18) | 1400 | 1200 | blast |
| BetAB-500 ShP | MiG-27 (2) | 425 | 350 | concrete-penetrating |
| ZAB-500 | Su-33 (6),<br>Su-24 (7),<br>Su-25 (8),<br>MiG-27 (4),<br>MiG-29 (4) | 500 | 480 | incendiary |
| RBK-500 | Su-33 (6),<br>Su-24 (8),<br>Su-25 (8),<br>MiG-27 (4),<br>MiG-29 (4) | 380 | 290 | cluster/fragm. |
| KAB-500 | Su-33 (6),<br>Su-24 (4),<br>Su-25 (8),<br>MiG-27 (2) | 560 | 380 | armor-piercing or blast |
| KAB-1500L | Su-24 (2),<br>MiG-27 (1) | 1500 | 1100 | blast |
| KAB-1500 KR | Su-33 | | | |

## *Unguided Rockets*

Despite the existence of high-accuracy weapons, unguided rockets remain a powerful and flexible 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 stabilizer. 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 stabilizer located in its tail part. It serves to align the longitudinal axis of the rocket with its velocity vector. As unguided rockets are usually carried in launching pods, the stabilizer fins are kept folded inside the launch tubes of the pod. When the pilot launches the rocket, the stabilizer fins flip out into a fixed position.

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

Depending on combat tasks, the pilot can employ unguided rockets of different caliber (from 57mm up to 370mm 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 armor-piercing warhead, or at a certain distance from the launching platform, as in the case of a flare warhead.

Hit accuracy is characterized 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 and by safety range. 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 diving 10–30°. By maneuvering 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 Rocket

The S-8 is a medium-caliber, unguided rocket (80mm in diameter) placed into the twenty-canister B-8 rocket pod. The S-8 has an effective range of 2000 m. The margin of error is roughly 0.3% of launch range; rockets fired at a range of 2000 m hit within a circle of 6 m in diameter. The S-8 is normally deployed with a shaped-charge fragmentation warhead effective against soft targets. Armor-piercing (capable of penetrating 0.8m of reinforced concrete) and fragmentation warheads are also available.

### S-13 Rocket

The S-13 is a 132mm, unguided rocket placed in the five-round B-13 rocket pod. 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 3 m of ground cover or 1 m of reinforced concrete. The S-13 has an effective range of 3000 m.

The S-13T variant carries a two-stage penetrating warhead which detonates inside the target after piercing the protective covering (up to 6 m of ground cover or up to 2 m of reinforced concrete). When the rocket hits a runway, it damages an area of about 20 square meters. The blast-fragmentation warhead of the S-13OF version produces about 450 fragments weighing 25–35 grams each, effective against lightly armored vehicles.

### S-24 Rocket

The S-24 is a large-caliber (240mm), unguided rocket fitted with a powerful, solid-fuel rocket motor. The motor operates for 1.1 seconds, accelerating the rocket and providing a stabilizing spin. 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 m.

The rocket is usually fitted with a proximity fuse, detonating over the target at an altitude of about 30 m. To destroy hardened targets, the S-24 may carry a delay-after-impact fuse. The warhead housed into a strong casing pierces the covering of the target and detonates inside.

### S-25 Rocket

The S-25 is a super-heavy unguided rocket housed in an expendable container. Inside its container, the rocket's four stabilizer fins are folded between four skewed jet nozzles providing stabilization spin-up.

There are several versions of the S-25 rocket in service with varying warheads effective against different target types. 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 armored vehicles, buildings, and personnel. The S-25-OFM has a modernized, 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 m with a margin of error of about 0.3% of launch range (rockets fired at a maximum of 2000 m will land within a 6 m diameter).

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

| Type | Carrier (#) | Range, km | Weight, kg | Warhead type |
|---|---|---|---|---|
| S-8B | MiG-27 (80), MiG-29 (80), Su-24 (120), Su-25 (160), Su-33 (120) | 2.2 | 15.2 | concrete-piercing |
| S-13OF/S-13T | MiG-27 (20), MiG-29 (20), Su-24 (30), Su-25 (40), Su-33 (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-33 (6) | 3 | 380 | blast-fragmentation |
| S-25OFM | Su-24 (6), Su-33 (6) | 3 | 480 | penetrating |

## Cannon Strafing

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 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.

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 meters, respectively.

# GROUND SCHOOL

Air combat is a complicated task; military pilots receive years of training and practice before being turned loose to fight for their country. Simulated air combat isn't as complicated, but a thorough understanding of basic flight and combat principals is required to ensure victory.

## 8.001 Indicated Airspeed and True Airspeed

All airspeeds are not created equal. Dense air at lower altitudes both increases the lift generated by the wings, and resists the aircraft's movement. Thinner air at higher altitudes reduces the amount of lift the wings can produce, but lets the aircraft move more easily. As a result, an aircraft moving at a constant 350 knots has different performance and flight characteristics at sea level than at 40,000 ft. This is called the aircraft's True Airspeed (TAS).

Most modern aircraft adjust the airspeed display to account for altitude. This Indicated Airspeed (IAS) displays the airspeed that would provide equivalent performance at sea level. For example, an aircraft flying at 350 knots IAS at 5,000 ft has the same performance as flying 350 knots IAS at 45,000 feet; however, its TAS is actually significantly faster at the higher altitude. Displaying IAS reduces the pilot's workload, minimizing the amount of flight performance data that must be memorized.

**►Some airspeed indicators show TAS; others show IAS. Always confirm the operation of each air speed indicator prior to takeoff.**

## 8.002 Velocity Vector

The velocity vector is an extremely important indicator displayed on most fighter jets' HUDs. The velocity vector shows where the aircraft's momentum is actually taking it. For example, any time you change course, the aircraft's momentum keeps it moving in the original direction until the thrust of the engines overcomes the momentum and establishes a new heading. Aircraft like the MiG-29 and Su-27 are famous for high AOA flight, in which case the aircraft's nose is pointing one direction, but the plane is actually moving a different direction. In this case, the velocity vector indicates where the aircraft is actually heading.

**►The velocity vector is useful during landings. If the velocity vector appears short of the runway, you're going to crash short of the runway!**

## 8.003 Angle Of Attack Indicator

Whenever the velocity vector is not aligned with the aircraft's heading, the pitch angle between the airflow and where the aircraft is pointing is called the Angle Of Attack (AOA). Anytime the pilot pitches the aircraft (whether in a steep turn, or just initiating a climb), the AOA increases. In level flight, reducing thrust generally increases AOA because the reduced thrust results in reduced lift. The aircraft begins to sink while holding a nose-level attitude.

AOA and airspeed impact the amount of lift (G-load) generated by the wings. Generally, if the wing isn't stalled, then increasing AOA will increase the amount of lift being generated. Likewise, increasing speed with a constant AOA also increases lift. Unfortunately, this also increases the drag generated by the wing, therefore causing the aircraft to slow down. Slowing down subsequently reduces lift and drag, allowing the aircraft to accelerate again.

**►A stall can occur at any altitude, airspeed, or flight attitude.**

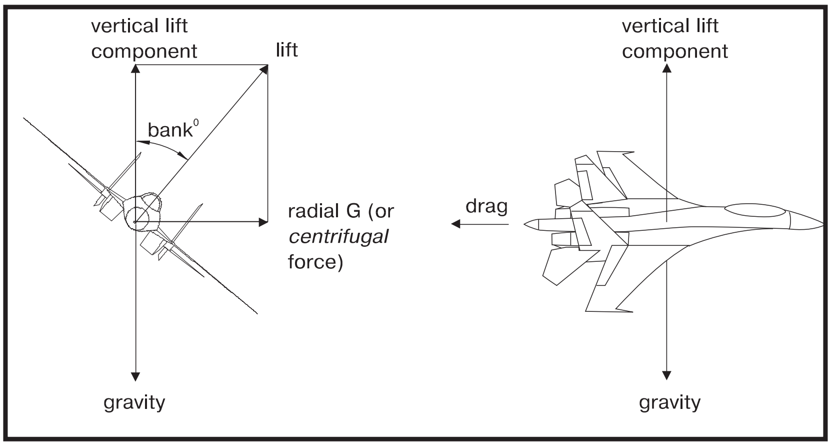
Increasing AOA eventually disrupts the airflow over the wing. This is called stalling the aircraft. During a stall, the reduced airflow over the wing severely decreases the amount of lift generated. A stall can occur at any altitude, airspeed, or flight attitude simply by increasing the AOA too much. A stall can have disastrous consequences during a dogfight, as explained below in the "Lift, Turn Rate, and Turn Radius" section. Learn to avoid stalling during a dogfight.

If the aircraft sideslips during a stall, the aircraft is likely to depart controlled flight. In most cases, this "departure" results in a spin, but some aircraft are prone to other types of rocking, pitching, and tumbling. During a departure, the pilot has no control over the aircraft and must focus on regaining controlled flight. To recover from a spin, reduce the throttle and apply rudder opposite to the direction of the spin. In most cases, pushing the control stick forward helps, also. Hold these flight controls until the aircraft stops spinning and responds to control inputs. It is common to lose several thousand feet of altitude during a spin.

**►To recover from a spin: Reduce throttle, apply rudder opposite to the direction of the spin. It often helps to push the control stick forward, also. Hold these controls until the aircraft stops spinning.**

## 8.004 Lift, Turn Rate, and Turn Radius

The lift vector (the direction of the g-load generated by the wings) is perpendicular to the wings. As long as lift equals gravity, the aircraft maintains a steady altitude. Banking the aircraft reduces the amount of lift directly opposing gravity.




How Bank Angle Affects G-Load

Aircraft performance is generally described in terms of turn rate and turn radius, both of which are dependent upon the aircraft's speed and the amount of lift, or g-load, being produced. Turn rate measures the speed at which the nose is moving around the circle, typically measured in degrees per second. A high turn rate means the aircraft could complete a 360° turn very quickly. Turn radius, as the name implies, measures the size of the aircraft's turn. The ideal fighter couples a low turn radius with a high turn rate.

## 8.005 Corner Speed

Increasing g-load improves both turn rate and turn radius. Increasing airspeed degrades both turn rate and turn radius. Recall from the discussion above on AOA, though, that increasing speed increases g-load, leading to a catch-22 situation. The trick is to maintain the appropriate speed that maximizes turn performance, called the corner speed.

**▶The corner speed produces the best combination of turn rate and turn radius.**

The corner speed produces the combination of the highest turn rate with the smallest turn circle. It may not necessarily be the absolute best turn rate or turn radius, but rather finds the point where the two attributes each have good values. Turning speed varies according to the aircraft, altitude, and drag from the external stores, but generally falls 300 to 400 knots.

**▶Try to maintain corner speed during close-in dogfights. Flying above or below corner speed degrades turn performance, giving your opponent an advantage.**

## 8.006 Sustained vs. Instantaneous Turn Performance

Instantaneous turn performance describes the absolute best turn performance the aircraft is capable of, generally at the lowest speed that produces maximum g-load. It only lasts for a brief moment, though, as high g-loads generate substantial drag, which quickly slows the aircraft, therefore reducing the available g-load.

**▶Turning hard bleeds speed, reducing turn performance.**

Sustained turn performance refers to the aircraft's "steady state" performance where the engines' thrust reaches equilibrium with drag. Sustained turn performance will be well below the instantaneous performance, but lasts significantly longer. Theoretically, the aircraft could maintain this turn rate and radius until it runs out of fuel.

## 8.007 Energy Management

The key to dogfighting lies in energy management. Energy comes in two forms: kinetic energy (speed) and potential energy (altitude). As described above, speed is required to produce lift, and lift is required to increase turn performance. The engines have limited thrust, however, and increased drag further slows the aircraft. The goal of energy management, therefore, is to ensure the ability to reach corner speed at any time during a dogfight.

**▶Turning too often or too hard wastes energy.**

Try thinking of energy as the money the aircraft uses to buy maneuvers. As with money, energy is usually in short supply. Careful management is required to ensure that there is enough energy available to "buy" the maneuver needed. Spending too much energy on unnecessary hard turns wastes the available energy. Like real money, once it's gone, it's gone.

Airspeed, or kinetic energy, equates to cash that can be used instantaneously to create lift and buy maneuvers. Altitude, or potential energy, equates to a savings account that can be quickly cashed out – by diving, the aircraft quickly converts altitude into airspeed.

**►Fail to manage energy and you'll find yourself out of airspeed, altitude, and ideas!**

Managing energy requires careful attention to flight maneuvers. Don't make unnecessary high-g turns. Don't waste altitude with unnecessary dives. During a dogfight, strive to maintain corner speed. If airspeed drops too low, "unload" the aircraft. Unloading simply means relaxing the back pressure on the control stick, which reduces AOA, which then reduces g-load, which then reduces drag and therefore helps the aircraft's engines maintain the desired airspeed.

**►Unloading the aircaft by relaxing the g-load reduces drag and helps the aircraft accelerate.**

# PRIMARY FLIGHT SCHOOL

Air combat accounts for very little of a pilot's total flight time. Taking off, navigating to the target, navigating back home again, and landing occupy most of a pilot's flight.

**▶If you can't find your way to the target, or can't find your way back home, you'll have a very short career as a fighter pilot!**

## 9.001 Navigating with the HSI

Modern combat aircraft provide excellent steering and navigational cues on the HUD. But what happens if the HUD is damaged? The Horizontal Situation Indicator (HSI) provides an integrated backup solution. Russian and U.S. HSI's differ somewhat, but both provide the same basic information:

- A pointer to the next steer point.
- The range to the next steer point.
- The aircraft's current heading.
- U.S. HSIs include a flight path deviation needle, which shows deviation from the desired flight path.
- Russian HSIs include ILS needles within the center.
- Russian HSIs include a wide needle which points to the desired flight path.

The pointer to the next steer point indicates the direct path from the aircraft's present position to the steer point. However, the programmed course may be designed to avoid enemy troops, SAM batteries, or AAA sites. In that case, it is better to use the course deviation indicators to find the desired flight path, and then use the steer point needle to proceed to the next steer point.

## 9.002 Landings

Landings distinguish good pilots from mediocre pilots and are the most critical part of flying.

**▶The secret to all good landings is the approach.**

During landings, generally fly a constant AOA until flaring just before touchdown. The AOA indexer, usually located near the HUD, provides a graphic indication of the required AOA. If the top light illuminates, the aircraft is too slow or the AOA is too high. If the bottom light illuminates, the aircraft is too fast or the AOA is too low. The middle light indicates a proper approach AOA.

**▶Move the stick as little and as smoothly as possible.**

During landings, proper procedure "reverses" the controls. The throttle, normally used to control airspeed, is now used to control altitude. Likewise, the control stick, normally used to change altitude, is used to control airspeed. Flying the approach, first establish the appropriate AOA. Then, if the aircraft accelerates too much, pull back on the stick and increase the pitch angle. This bleeds speed and slows the aircraft. If the aircraft slows down, drop the nose a little to pick up speed. Meanwhile, if the altitude drops too fast, increase throttle. If the altitude climbs, reduce throttle.

Alternatively, some pilots live by the motto, "Aimpoint, airspeed." In other words, using the velocity vector or visual steering, point the aircraft such that it is heading for the end of the runway (the aimpoint). Next, adjust airspeed to the appropriate landing speed. By maintaining both attributes, the aircraft will follow a proper approach.

Always use the proper speed to maintain the correct AOA during final approach. The following table provides an estimation of the speed required for empty aircraft:

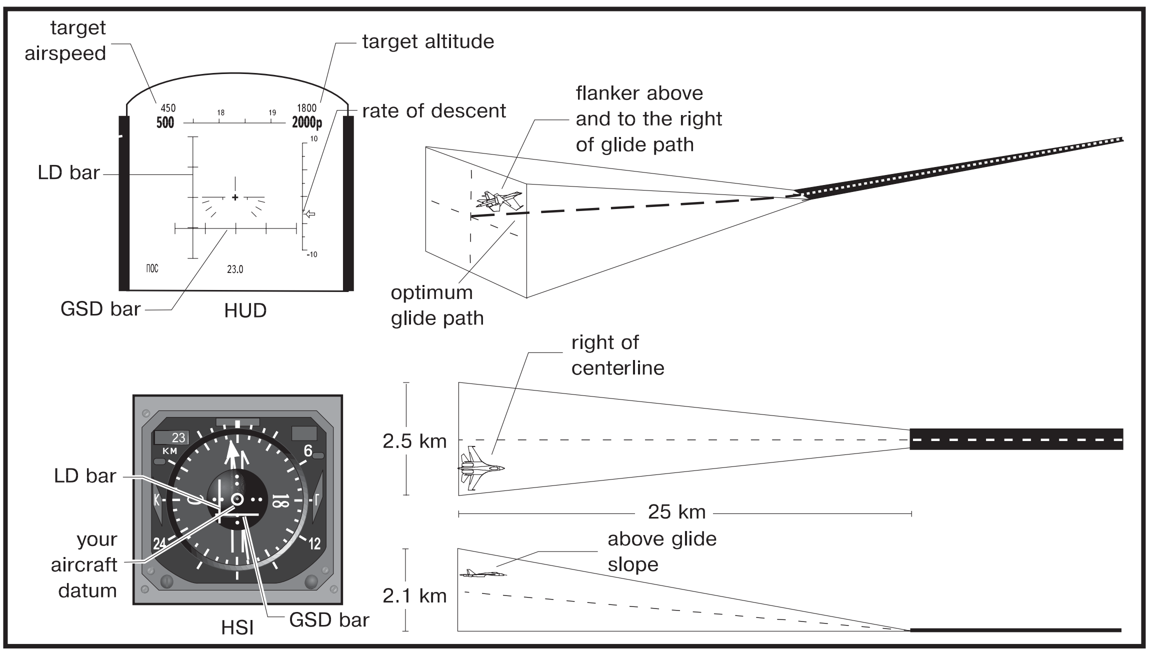
| Aircraft (Clean) | Final Approach Speed | Touchdown Speed |
|---|---|---|
| Su-25 | 280 km/h | 210 km/h |
| Su-27 | 300 km/h | 250 km/h |
| MiG-29A | 280 km/h | 235 km/h |
| F-15 | 125 knots | 115 knots |
| A-10 | 120 knots | 110 knots |

**►If flaps are unavailable, increase speed by 10 knots or 15 km/h. If carrying significant fuel or stores, increase approach speed as necessary to maintain correct AOA.**

Always steer to land the aircraft with the nose wheel directly on the runway centerline. As the saying goes, "The centerline is for pilots. The rest of the runway is for passengers."

## 9.003 Instrument Landing System (ILS)

Both Russian and U.S. aircraft use the same Instrument Landing System (ILS). The ILS uses two needles to guide the aircraft down the proper approach trajectory, called the glide path. The horizontal glideslope deviation bar shows the desired altitude. The vertical, localizer deviation bar shows the desired heading. When the needles are centered, the aircraft is flying the correct glide path. If the aircraft is off course, the needles drift outwards. Always fly toward the needles; if the localizer bar drifts to the right, turn right. If the glideslope bar drops, descend.




The ILS System

## 9.004 Crosswind Landings

Crosswind landings are a little more difficult since the wind is pushing the aircraft across the runway. Turn slightly into the wind, keeping that wing dipped. Point the aircraft slightly off the side of the runway. Right before touchdown, level the wings and turn directly onto the runway. Alternatively, apply rudder toward the wind, flying at a constant sideslip. Many pilots find the second technique easier; however, in a strong crosswind, the sideslip angle may be prohibitive.

**▶Avoid crosswind landings if the crosswind speed is greater than 30 knots.**

# AIR COMBAT BASICS

## Strategy and Tactics Overview

Modern technology has completely revolutionized the battlefield in less than a century. Aircraft, in particular, have advanced from little more than motor-powered kites to modern combat jets in just a few decades. Defense contractors and military officials often cite the strengths of their vehicles, but rarely mention the major shortcomings in public. Consequently, many people develop an opinion that aircraft (and other battlefield platforms) are more capable than they really are.

The primary reason flight-simulator pilots get shot down is inappropriate usage of their platform. Keep in mind that surface-to-air defenses and enemy aircraft have made the same technological leaps. True, today's aircraft are significantly more powerful and resilient than their WWII counterparts; at the same time, enemy gunfire is much more accurate, powerful, and able to fire at longer ranges. In short, the battlefield is a more dangerous place than ever before.

## Understanding Enemy Air Defenses

Enemy air defenses, including surface-to-air missiles and anti-aircraft artillery, are an integral part of the modern battlefield. Interlinked defense nets let defense sites across the battlefield communicate and share information. Pilots must possess a thorough knowledge of (and a strong respect for) such systems, or they'll find themselves riding a parachute with alarming frequency.

## AAA

In general, Anti-Aircraft Artillery (AAA) is effective against low-flying targets and mainly serves for covering troops from enemy aircraft. Many armies have multi-barreled mobile AAA systems fitted with radar and a fire-control system that provide effective operation in any meteorological conditions. In contrast to ground forces, ship-borne artillery usually has a multipurpose character, and fighting against airborne targets is just one of their several 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.

Land-based systems, like the ZSU-23-4 Shilka (pronounced 'shil-ka') employ mutli-barreled cannons, off-road mobility, and high rate of fire. Usually equipped with its own radar, self-propelled AAA usually has some backup aiming method, such as an IR or optical seeker.

To destroy low-flying airborne targets, combat ships use multipurpose guns that can also be used against enemy ships and coastal defense. For the most part, shipborne artillery is classed as 100 to 130mm guns (heavy caliber), 57 to 76mm guns (medium caliber), and 20 to 40mm guns (small caliber). All guns have a high degree of automation of aiming, loading, and firing. Automatic small-caliber (20-40mm) anti-aircraft guns are mainly effective against low-flying aircraft and cruise missiles. Since SAMs normally have a substantial minimum range (within which airborne targets cannot be hit) ship-borne AAA is used as a short-ranged, point - defense weapon. Firing around 1,000 rpm per barrel, such weapons create a nearly impenetrable cloud of metal between the target and the ship. Such 30mm guns have an effective range of 5,000 m; however, range is less important than rate and density of fire.

## SAMs

Surface-to-air missiles (SAMs) form the backbone of the air defense network, integrating each search-and-track sensor with every unit on that network. Short-ranged, Man Portable Air Defense Systems (MANPADS) carried by infantry troops fill any gaps.

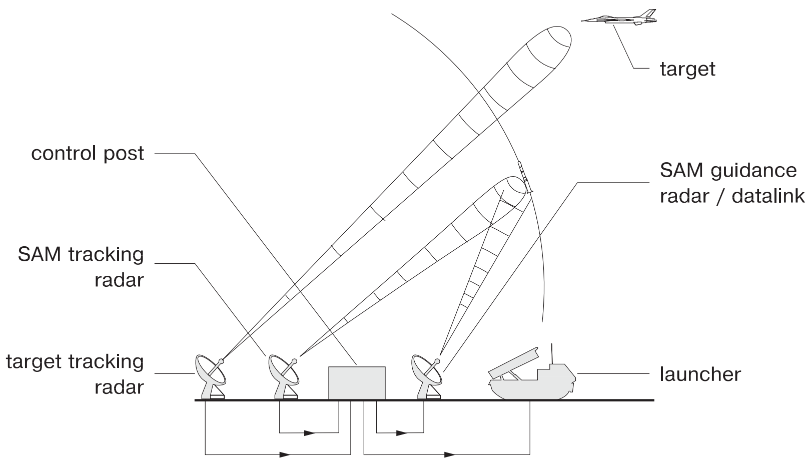
The main elements of a SAM (airframe, guidance system, fuse, warhead, and rocket motor) are similar in design and function to those of AAMs. In addition, some SAMs utilize exhaust-deflector vanes for additional maneuverability.

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, semi-active beam-rider guidance, homing, and combined guidance.

### Command Guidance

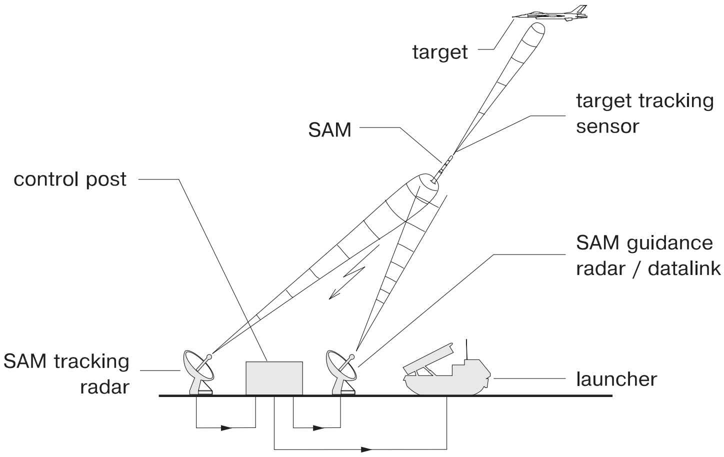
Command guidance may be compared to classic remote control. During the SAM's flight, the positions of both the target and the missile are monitored from the ground or by the missile's onboard equipment.

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 SA-15 and SA-8), since the guidance accuracy decreases as the range increases.




A Typical Defense Network

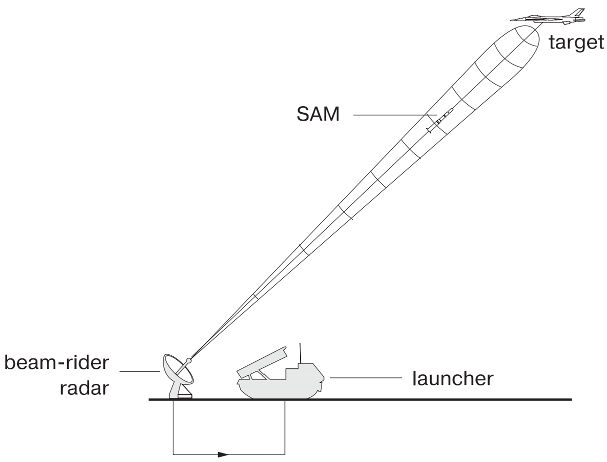
If the SAM itself can track the target, it measures and processes the parameters of the target's motion and sends them to the control post through radio data link. The coordinates of the SAM itself are measured by a ground-based tracking radar. Again, after comparing the coordinates of the SAM and of the target, the control post sends guidance commands to the SAM. Long-range SAM systems such as the S-300 (SA-10B Grumble) usually employ this type of command guidance in mid-course.




Command Guidance Sends Course Updates to the Missile

## Beam-Rider Guidance

Semi-active, 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 center 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 "highlights" the direction to the target. Like command guidance systems, beam-rider SAM systems are not limited to daylight and good-weather conditions.




Beam-Riding Missiles Follow the Guidance Beam to the Target.

One problem with beam-rider systems, as with command ones, is that the SAM must have high maneuverability in order to intercept an evasive target. As they approach the target, beam-rider missiles often must tighten their turns continually to keep up. 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 semi-active homing, the source of illumination (tracking radar) is located at the control post, and the SAM receives signals reflected from the target. Passive homing systems use heat or light emitted by the target to estimate the parameters of the target's motion.

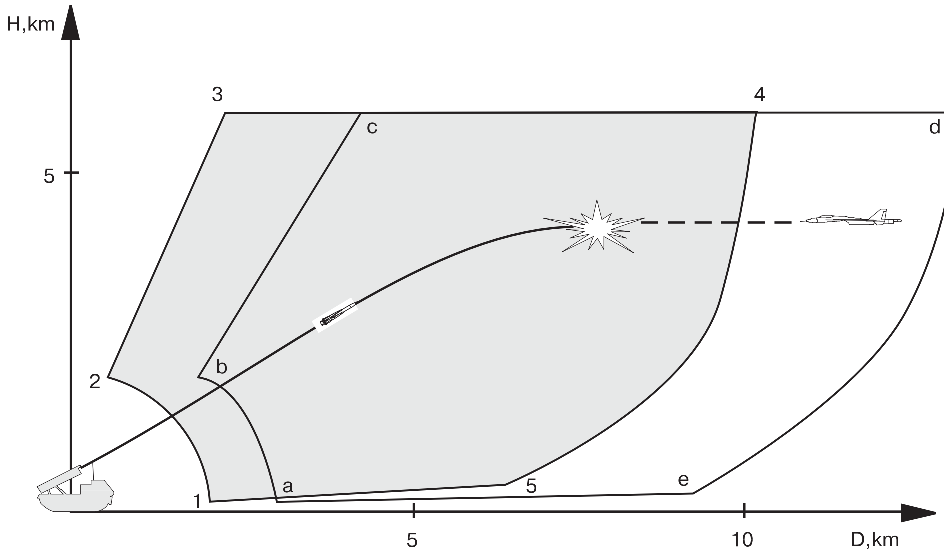
In general, homing systems operate in the following way: while the SAM rests on the launcher, its seeker is locked onto the selected target, and the parameters of the target's motion are being measured. After launch the SAM seeker tracks the target, estimates the tracking error, and produces control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

## Combined Guidance

As the name implies, some missiles combine guidance methods to improve performance. 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

Like air-to-air missiles, SAMs have specific engagement envelopes. Firing at targets within the heart of the envelope increases the likelihood of a hit. Just like air-to-air missiles, the envelope varies based on the target's range, altitude, and aspect. In the engagement diagram shown, the area defined by the numbers 1, 2, 3, 4, and 5 represent the missile's effective area. Note that this envelope shifts if the target is moving toward the launcher, in the area defined as a, b, c, d, e. In this case, the missile must be fired at longer range since the target will fly part of the way into the missile. If the missile is fired too late (once the target has crossed the a, b, c line), it passes out of the envelope before the missile arrives.




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. 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's radar cross-section (or effective reflection area) and altitude, and varies substantially against different-sized targets. If for a certain target the effective range of the radar is less than that of the SAM, this will decrease the engagement envelope. SAMs are generally classified based on their range as:

- Long-range (>100 km)
- Medium-range (20 to 100 km)
- Medium-and-short range (10 to 20 km)
- Short-range (<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 the 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 m at a distance of 20 km and 150 m 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 m 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.

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, therewith 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.

## The Defense Network

Modern military forces link their early-warning and tracking radars via an interlinked network. This allows one search (or tracking) radar to share data with every other user on the same network. Consequently, the SAM launcher may not have to transmit from its own radar, instead relying on guidance from other tracking devices located elsewhere on the net. It may appear that all enemy radar sites are located several kilometers ahead of you, but you may be directly over the enemy launcher!

"Blinking," whereby different tracking radars on the network take turns tracking the target and guiding the inbound missile, is a very common practice. No one radar stays on long enough for your forces to counterattack, and the heading of the radar warning continually changes on your radar warning receiver. When caught in such a SAM trap, you must visually locate the incoming missiles, take the appropriate evasive maneuvers described later in this chapter, and get out of the trap as quickly as possible.

## Countering Against Enemy Air Defenses

Successfully penetrating the enemy air defense network is difficult. The following suggestions will help you punch through, engage the target, and make it safely home again.

## Don't Get Shot At

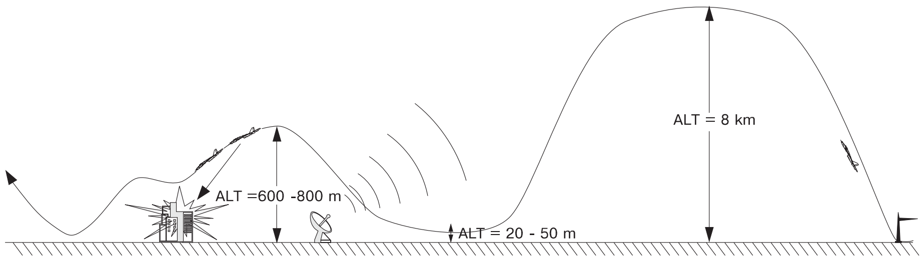
It may seem rather obvious, but the best way to avoid being hit by a missile is by preventing the enemy from ever launching one. Fighter jets are often portrayed as modern knights roaming the skies in search of a duel, but are in actuality more like cats. Skillful hunters and powerful killers, they try to slip by silent and unseen while stalking unsuspecting prey. Try to avoid enemy air defense concentrations whenever possible. If possible, flight paths should be routed toward known weak spots or other areas which have been heavily attacked.

Also, don't wander from the instructed flight path. Other aircraft and ground forces will usually be working to keep a corridor open for you. Straying out of this corridor and into enemy SAM traps is usually fatal and is a common problem for simulation pilots.

## Suppression of Enemy Air Defenses

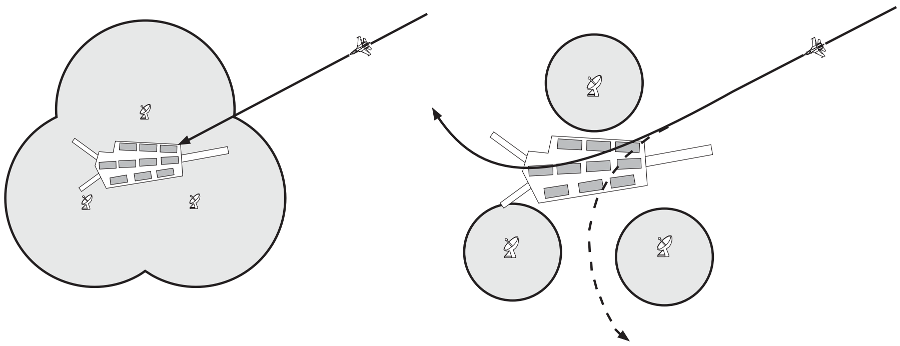
The Su-27, being rather large, isn't particularly stealthy. The pilot, therefore, must rely on tactics to mask his presence from the enemy. Perhaps the most effective way of preventing the enemy from firing is simply to shoot first. This generally means detecting the bad guys early, making a discreet approach, firing first and getting out fast. By launching a fire-and-forget anti-radar missile, such as the Kh-31p, the targeted SAM is forced to switch off its own radar to have any chance of surviving. In air-to-ground terms, strike forces should generally be accompanied by a SEAD escort: two or more aircraft equipped to engage enemy air defenses and radar sites.

## Low-Level Flight




A Typical Hi-Low-Hi Ingress Profile

Such a brute-force, kick-them-in-the-teeth approach may not always be possible. There may not be sufficient aircraft available, or the enemy may have taken out friendly GCI radars. In this case, terrain masking may be the best choice. As the name implies, pilots fly extremely low (as low as 30 m above the ground in some cases), using hills, mountains, and other landscape features to remain discreet. All tactical detection systems rely on line-of-sight between the sensor and the target. Laser, radar, optical, and IR detection and tracking systems cannot penetrate hills and other such obstacles. Such nap-of-the-earth (NOE) flight is very effective, but is also very dangerous. At high speed and low altitude, the slightest mistake can result in an immediate crash. Also, AAA units will generally be placed to protect low-level ingress routes to high-value targets, further increasing the hazards of flying low. This type of tactical flying will not be effective against modern AWACS tracking, but will keep you clear of most AAA and SAM risk.



The Effects of Target Altitude on Radar Propagation. Flying High (Left) Increases Chance of Detection as Opposed to Flying Low (Right).

## AAA Counter Measures

AAA systems generally cannot engage targets above 1,500 m above them. That does not necessarily mean that flying 1,501 m above sea level renders you immune to AAA. The enemy will often place AAA on hilltops or ridgelines, thus increasing their effective altitude. Generally, the best way to evade AAA is to simply climb above it. Inside its engagement envelope, however, AAA is deadly. When AAA fire suddenly erupts around you, always remember:

1. Be unpredictable. Any erratic jinking maneuvers will help disrupt the AAA's fire-control computers.
2. Don't waste energy. Each time you pull the stick to maneuver, you bleed energy and airspeed. Keep weaving, but don't slow down.
3. Don't fly in circles. Make your turns erratic and unpredictable. Whatever you do, keep flying along a general course that takes you away from the AAA. Don't fly circles above it.

If you're near its effective altitude limit, you might be able to engage afterburners and quickly climb above it. This, however, poses two potential problems. First, you'll present a nice, easy target while climbing. Second, by increasing altitude you increase the likelihood of being detected by other air defenses or aircraft.

## Evading Missiles

Missiles are tough opponents; they are, in general, 2–3 times faster, can pull 3–4 times mores g than you, and are small and hard to track visually. Successfully evading a missile depends on many factors, such as how quickly you detect the missile and how deep you are within the weapon's launch envelope. Depending on the circumstances, you have several evasive maneuvers to choose from; choose the wrong one and the missile, quite literally, will follow you for the rest of your simulated life.

Fortunately (for the target aircraft), missiles are bound by the same laws of physics as the aircraft they chase. That is, despite having much more power available than aircraft, they bleed speed in a turn just like a fighter, and missile turn- rate and turn-radius performance depend on the missile's overall energy state. The trick to defeating missiles, therefore, is making them run out of energy before they get to you.

### Launch Warnings

Launch warnings come from a variety of sources. In some circumstances, a wingman might see the launch and issue an appropriate warning over the radio. In some cases, your radar warning receiver might indicate the enemy is tracking you. In most cases, though, the best indication of an inbound missile is visual detection. When in hostile territory, constantly scan the area around you for puffs of smoke (indicating a launch) or long smoke trails that extend behind most missiles while the motor burns. Remember to scan the ground as well as the sky, as these indicators may betray a SAM launch as well as an air-to-air launch.

Keep in mind that once the missile's motor burns out, it will stop producing a smoke trail, so early detection is critical. Long-range air-to-air missiles generally climb to high altitude, then dive on the target, so be especially alert for rainbow-shaped smoke trails coming toward you!

### Knowledge Is Power

Your first weapon is knowledge - knowledge about your enemy's capabilities and his position. For example, assume that a U.S.-built AMRAAM has a nominal range of 45 km at 5,000 m. You've conducted a thorough radar sweep of the area ahead of you and are certain that the only targets around are a pair of F-15s about 40 km away. Suddenly, you see the tell-tale smoke trails of inbound missiles. Since you know these missiles were fired near maximum range, you can probably out-run them. Execute a corner-speed, turn 180° away, then unload to 1 g, and accelerate directly away by diving at 30–45° at full afterburner.

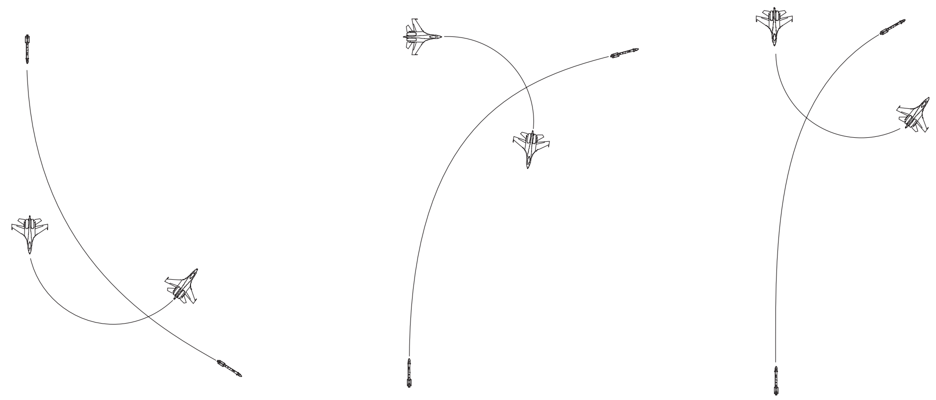
Success depends primarily on how quickly the target can turn (a clean fighter may be able to pull a 9 g turn, a heavily laden jet may be limited to 5 g) and how quickly it can accelerate after that turn. If you receive warning of the launch soon enough, you stand a good chance of out-running the missile. If you're late picking up the missile or the target waits until you're deep in the launch zone before firing, this method probably won't work.

## Fight Missiles with Aspect

Most modern missiles fly lead as opposed to pure-pursuit paths to the target. That means each time the target changes course, the missile changes course as well. A lead-pursuit missile will attempt to hold a constant lead angle enroute to the target and appear to remain stable on your canopy relative to the horizon. A pure-pursuit missile will appear to remain pointed directly at you, but its position will drift back toward the back of your aircraft. For the most part, if the missile appears in a relatively constant position while steadily growing larger, it's successfully tracking your aircraft. If the missile appears to be rapidly moving across your canopy, it's probably going to miss you (or is tracking somebody else).

**►If a missile appears stationary on the canopy while growing steadily larger, it is probably on intercept course. If it's rapidly moving across the canopy, it probably won't hit you.**

Since missiles, like aircraft, need energy to maneuver and bleed speed while maneuvering, you want to make the missile maneuver as much as possible. The more you maneuver, the more work the missile must perform and the more energy it will bleed trying to adjust to your maneuvers. This forces the missile to fly a curved path to the target, bleeding speed and energy along the way.



Beaming an Inbound Missile

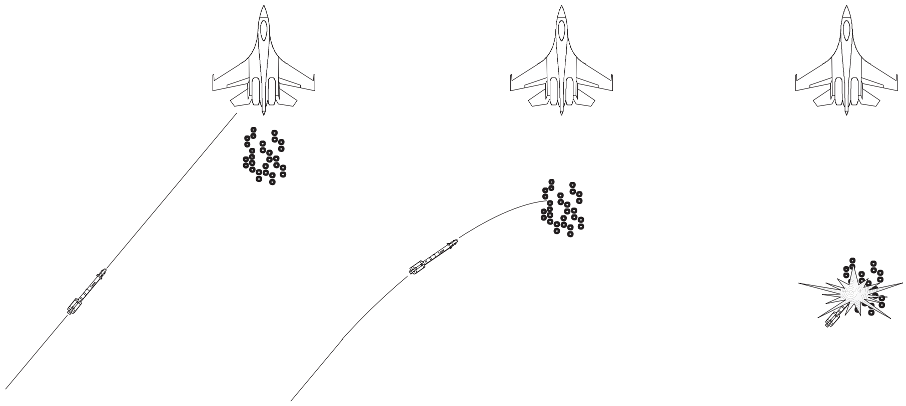
Begin by "beaming" the target; that is, executing a corner-speed, turn toward the missile to place it exactly 90° off your nose (to either your 3 o'clock or 9 o'clock position). Once you have the missile directly on your 3/9 line, pull just enough g-load to keep it there. The missile has a limited field of view, much like the beam of light emitted from a flashlight. If you pull a continuous 9 g turn in the middle of that "beam," the "flashlight" will fly up and punch a hole through your aircraft.

Instead, you want to fly toward the edge of the beam, known as the gimbal limit moving as fast as possible across the missile's field of view. By maneuvering to the edge of its field of view, you force it to make the largest corrective maneuvers. In the best case, you might move out of its field of view; in the worst case, you make the missile bleed as much energy as possible. Keeping the missile directly on the 3/9 line also points your hot engine exhaust away from an IR missile's seeker. Beaming may also present problems for Doppler radar systems, although remember that you're beaming the missile, not the launching platform.

Like the aforementioned flashlight beam, the missile's field of view grows wider at longer range. Consequently, at long range you'll pull minimum g. As the missile gets closer, you increase the g-load as necessary to keep it stationary on your 3/9 line. If the missile appears to move toward your nose, you're pulling too much g and basically turning inside the missile's field of view.

**▶If the missile doesn't make constant corrective actions after you begin beaming, it probably is tracking someone else.**

Be sure to release chaff and flares while maintaining this turn, especially as the missile gets closer. If you start too early, the missile will not be spoofed. Each press of the Q key releases one chaff (effective against radar-guided missiles) and two flares (effective against heat-seeking missiles) from the APP-50 dispenser in the tail boom. The system releases both since pilots rarely know exactly which type of missile is approaching. These decoys may present a more attractive target in the middle of the seeker's field of view. The missile may turn toward them, allowing you to pass out of its field of view. Modern missiles are fairly smart, though, and can often tell the difference between a quickly-decelerating bundle of chaff and your aircraft.



How Chaff/flares Spoof Missiles

Flying a steady flight path, followed by a high-g break turn at the last second before missile impact, probably won't work. When the missile realizes it's overshooting the target, it will detonate and (depending on the missile's blast radius) seriously damage your aircraft. Instead, make the missile work all the way and give it a generous number of chaff/flare decoys to sort through.

**▶Don't fly into your own decoy. Although the decoy will drift somewhat, it remains relatively stationary compared to the speed of your jet. If you continue a steady turn after releasing chaff/flares, you'll eventually fly full circle, right back around to it. Since you're trying to spoof the missile, put as much distance between you and the decoy as possible. Also, after firing a flare, disengage afterburner if practicable. This will make the flare appear an even brighter and better target than your aircraft.**

## *Jamming*

ECM Active jamming, also called Electronic Counter Measures (ECM), is designed to confuse inbound missiles by presenting them with false radar information. Jamming attempts to transmit signals in the appropriate frequency band, which overpower and mask the normal radar returns reflected by the target. If the radar source closes on the target, it will eventually reach "burn-through" range, at which point the reflected energy from the target is stronger than the false signals sent from its ECM gear.

The ECM gear doesn't actually make the missile go madly off into the wild blue yonder. Instead, it generally increases the distance between the missile and the target when the missile detonates. By sending false signals, the ECM gear may make the missile think it's closer than it actually is. By manipulating the frequency of the false signals, it can create false Doppler shifts, further confusing the missile.

Consequently, we can see that the jamming equipment must be specifically tuned for the threat at hand. Broadcasting high power across a wide spectrum is relatively difficult; therefore, the jamming equipment is usually configured to defeat the threats most likely to appear during a given mission. Consequently, successful jamming depends on intelligence gathering equipment to ensure the ECM gear is operating in the appropriate frequency ranges. Multiple jammers should be used if a wide variety of threats are anticipated.

Jamming has one drawback: it announces its presence to everyone for miles around. Imagine someone shouting at the top of their voice during a business meeting. The loud noise prevents other attendees from communicating but also draws attention to the screamer. Likewise, jamming may block the immediate threat, but also draws attention.

The Flanker normally carries a built-in ECM pack, providing defense against airborne and ground-based radars. The status of the jammer is indicated by the AG indicator on the instrument panel. The aircraft can also carry the Sorbtsiya-S ECM system (roughly similar to the U.S.-built AN/ALQ-135 jammer), which is installed in two pods on the aircraft wingtips. It can detect and recognize illumination sources and jam that frequency. If the enemy radar shuts down, the system automatically ceases jamming.

### The Whole Package

In general, no one system (maneuvering, decoys, and jamming) is sufficient to spoof an incoming missile 100% of the time. Correctly combining appropriate maneuvers with well-timed decoys in a jamming environment, though, presents a formidable obstacle to inbound missiles. The key to survival, though, is early detection of enemy missiles. The earlier you see the missile, the more time you have to defeat it.

## Air-to-Air Tactics

The Su-27 was built as an air superiority fighter. Despite the addition of air-to-ground ordnance (especially on the Su-33), the air-to-air is a primary part of the Flanker's mission. The main goal of air-to-air engagements usually isn't to let the situation degrade into a dogfight. Especially for interceptor aircraft like the Flanker, the goal is to engage enemy aircraft at long range before the enemy can counter attack. Ideally, the enemy aircraft are destroyed, but merely forcing them to abort their mission is often sufficient. In military terms, this latter case is called a "mission kill."

## Searching For Targets

The Su-27 carries a very powerful radar, but can only provide weapons tracking information against one target at a time. The Su-33, however, can provide weapon targeting and launch solutions for two targets simultaneously. Ideally, long-range counter-air missions should always include AWACS support. With AWACS information datalinked directly to the Flanker, enemy aircraft will be painted on the MFD even if the Flanker's radar is inactive. Keeping the Flanker's radar deactivated reduces the chances of being detected by enemy aircraft (remember, enemy aircraft can detect your radar transmissions about two times farther away than your radar can detect that aircraft). Use AWACS data (or other datalinked radar information) to trap or ambush the enemy.

If AWACS isn't available, then the aircraft assigned to the mission must conduct their own air searches. Keeping in mind the limitations of the scan cone, flight leaders should order formations that allow effective searches of wide areas. Two aircraft flying in close, finger-tip formation effectively limits both aircraft. Horizontal separation lets two aircraft search a wider area; vertical separation lets them search a taller area.

Vertical and horizontal spacing also complicates the enemy's ability to track and detect friendly aircraft. Enemy search radars on fighter aircraft also have limited scan cones. Widely spacing friendly aircraft may keep some of them outside the enemy scan cone. Further, this aircraft is free to maneuver while the enemy focuses attention on the detected aircraft. The second aircraft can maneuver around and engage the enemy from its flank or rear while the first aircraft lures the enemy fighters into the trap.

When forced to conduct your own long-range searches, keep in mind that the radar cross section (RCS) of the target determines how far away the Flanker's radar will detect it. Large bombers will generally be detected much farther away than tactical aircraft. Also, ground clutter generally helps mask targets. Consequently, lower-altitude targets usually can't be detected at longer ranges.

## Maneuvers

While the goal of any interceptor is to engage with long-range missiles and escape, dogfights inevitably erupt.

**► Air combat is not a chess game. Pilots do not use specific maneuvers to "counter" enemy movements. Air combat is a fluid, dynamic, constantly changing environment. Rather than thinking "he did a split-S, so I'll counter with a high yo-yo," pilots instead consider where they need to point their aircraft in order to employ their weapons. They then execute the appropriate maneuver to adjust their lift vector and bring their aircraft into a firing position.**

### The Break Turn

The most basic defensive maneuver is the break turn. In this case, the pilot turns toward the threat aircraft to increase aspect angle and ruin the opponent's firing solution. Generally speaking, a break turn indicates a maximum-performance turn, using all available instantaneous g.

As an attacker, if the target executes a defensive break turn, you will generally resort to the high yo-yo to prevent overshooting.

### The High Yo-Yo

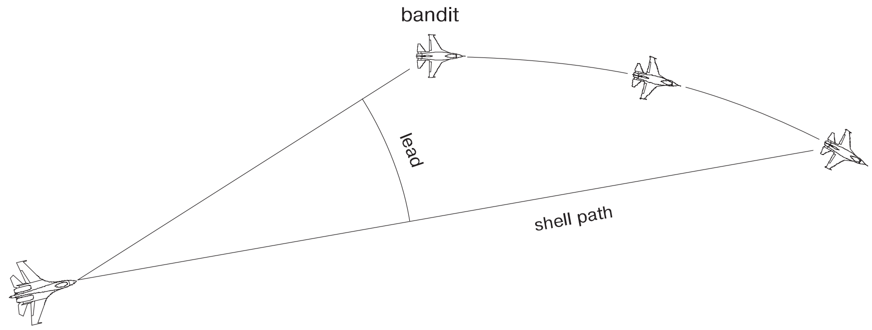
The high yo-yo uses a relatively quick movement out of the target's plane of motion to either slow closure rate or to reduce aspect angle to the target. The high yo-yo is performed by rolling slightly behind and above the target,extending behind the target's flight path for a moment, then rolling back toward and pulling the nose down to the target. The high yo-yo generally increases the range to the target, but decreases the aspect angle, setting up a firing opportunity. The length of time between rolling away from the target until pulling back into the target determines how "big" the yo-yo is. Generally speaking, executing a series of small yo-yo's to slowly nibble away at a large angular problem is better than executing one large maneuver.

If you have an adversary executing high yo-yo's behind you in order to gain a firing position, watch the enemy's nose closely. Your movement away from him helps solve his closure rate or aspect angle problem. Whenever his nose comes off (that is, is pointed behind your flight path), relax your turn and accelerate, thus increasing your energy status. As his nose pulls back into firing position, increase the g-load and tighten your turn. Conserve your energy when his nose is off, spend your energy as he brings his nose toward a firing position.

## Aerial Gunnery

Firing a gun from a moving platform, and trying to hit another moving platform executing evasive maneuvers, is no trivial task. To begin with, the bullets take a finite amount of time to leave the barrel and travel to the target; the further away the target is, the longer each projectile takes to cover the distance. During that time of flight, the target will probably execute some form of evasive maneuver; he probably won't be in the projectile's flight path by the time it gets there. So, the shooter has to "lead" the target: predict where it will be by the time the bullets get there and then fire at that point, hoping the target flies into the projectile stream. Meanwhile, gravity tugs on the projectiles, pulling them toward the ground. The farther and slower the projectile flies, the more the bullets drop. The shooter must factor this drop into the lead calculations as well.

Meanwhile, the shooter is moving also. Since he's chasing the target, he's probably flying a curved flight path. Consequently, his tracer stream appears to "bend" away since the individual rounds continue on a straight flight path. If all goes according to plan, the shooter aims ahead of the target, fires, and watches the tracers appear to fly a curved path to intercept the target.




Based on this scenario, we see that the range to the target is arguably the most important aspect of aerial gunnery. The further away the target is, the longer the bullets fly. Consequently, the shooter must lead the target more and account for greater drop due to gravity. As most WWII pilots (who did not have the benefit of pickling off a guided missile) discovered, don't shoot until the enemy aircraft fills the view. The closer you are, the more likely you'll hit something. Deflection shooting, or the art of appropriate leading a maneuvering target, increases in difficulty as range-to-target increases.

**▶Aerial gunnery can be summarized in three steps:**
**1. Match the target's wings.**
**2. Pull lead.**
**3. Shoot.**

## *Tracking Shots vs. Shots of Opportunity*

A tracking shot refers to a relatively slow, methodical approach to the target, achieving a stabilized firing position, and shooting the target. The shot of opportunity, on the other hand, refers to the brief moment when a target aircraft suddenly (and perhaps unpredictably) crosses your nose. You have mere moments to react, but a quick burst of gunfire is likely to score a hit if fired in time.

Whereas opportunity shots rely primarily on your reflexes, tracking shots require more finesse. In particular, you generally need to be in the same two-dimensional plane of motion as the target. This is defined by two vectors, the forward velocity (or longitudinal axis) and the lift vector (which is perpendicular to the wings). Although a good deflection shooter, especially equipped with a modern HUD and Shoot Cues, may be able to achieve the appropriate lead, maneuvering in-plane with the target aircraft greatly increases your chances of scoring a hit.

How do you maneuver into the target's plane of motion? By matching the target's wings. You can obtain a high-percentage tracking shot by maneuvering behind the target, matching the bank angle of the target's wings, then pulling sufficient lead based on the range to the target. When executed properly, the target should fly straight into the "bending" stream of your tracers.

# WEAPON USAGE

Each aircraft has slightly different weapon employment procedures, primarily a function of differing Eastern and Western design philosophies. The following section describes the basic procedure for acquiring targets and firing different types of weapons. Complete details on radar operation and weapon capabilities are provided in the chapters on Sensors, HUDs, and Weapons.

After selecting the desired weapon, all delivery methods share a three-step process:

1. Detect a target.
2. Lock the target.
3. Release the weapon.

## 11.1 F-15C

### 11.101 Using AIM-120 AMRAAM

**Step 1:** Search for targets by using the radar in RWS or TWS modes.

**Step 2:** When using RWS, switch the radar to STT mode by designating a target. When using TWS mode, simply designate up to eight targets. For close-range encounters, select FLOOD mode.

**Step 3:** Monitor the range cues in the HUD and MFD (FLOOD mode does not provide range cues). Fire when appropriate.

**▶ The radar must have a target locked in STT or designated in TWS before firing an AIM-120.**

### 11.102 Using AIM-7 Sparrow

**Step 1:** Search for targets by using the radar in RWS or TWS modes.

**Step 2:** If using RWS mode, switch the radar to STT mode by designating a target. When using TWS mode, designate the desired target twice to switch to STT mode. For close-range encounters, select FLOOD mode.

**Step 3:** Monitor the range cues in the HUD and MFD (FLOOD mode does not provide range cues). Fire when appropriate.

**▶ The Radar must have a target locked in STT or a target within the FLOOD mode pattern before firing an AIM-7.**

### 11.103 Using AIM-9 Sidewinder

**Step 1:** Search for targets by using the radar in RWS, TWS, vertical search, boresight, or home-on-jam mode.

**Step 2:** When using RWS mode, switch the radar to STT mode by designating a target. When using TWS mode, designate the desired target twice to switch to STT mode. For close-range encounters, uncage the missile's seeker head and let it search for the target.

**Step 3:** If using radar, monitor the range cues in the HUD and MFD. If using the missile's seeker head, wait for the acquisition tone. Fire when appropriate.

**▶The Radar must have a target locked in STT or acquired by the missile's seeker head before firing an AIM-9.**

### 11.104 Using 20 m Cannon

**Step 1:** Search for targets by using the radar in RWS, TWS, vertical search, boresight, home-on-jam, or gun auto-acquisition mode. (Using the gun auto-acquisition mode automatically selects the cannon as the active weapon.)

**Step 2:** When using RWS mode, switch the radar to STT mode by designating a target. When using TWS mode, designate the desired target twice to switch to STT mode.

**Step 3:** Steer the pipper over the target and fire when in range.

**▶You may fire the cannon visually, without a radar-locked target.**

## 11.2 A-10A

The A-10A carries no onboard radar, so target detection generally occurs manually or by using built-in missile seeker systems.

### 11.201 Using AIM-9 Sidewinder

**Step 1:** Visually search for targets.

**Step 2:** Uncage the AIM-9's seeker head and let it search for the target.

**Step 3:** Wait for the acquisition tone. Fire when appropriate.

**▶The missile seeker head must acquire the target before launching an AIM-9.**

### 11.202 Using Iron Bombs (Mk 82, Mk 84, and Mk 20 Rockeye)

**Step 1:** Visually search for targets.

**Step 2:** Steer the CCIP pipper over the target. Steady the aircraft controls, flying a stable flight path.

**Step 3:** Release the weapon when the pipper is over the target.

**▶You must stabilize the aircraft before releasing iron bombs. Any pitch, roll, yaw, or airspeed changes will throw the bomb off course.**

### 11.203 Using Rockets

**Step 1:** Visually search for targets.

**Step 2:** Steer the rocket pipper over the target. Steady the aircraft controls, flying a stable flight path.

**Step 3:** Release the weapon when in range.

**You must stabilize the aircraft before firing rockets. Any deviation in pitch, roll, yaw, or airspeed will send the rockets off course.**

### 11.204 Using Air-to-Ground Missiles (AGM-65B, AGM-65D)

**Step 1:** Visually search for targets.

**Step 2:** Steer the AGM-65 seeker over the target area and designate.

**Step 3:** Slew the aiming cross over a valid target and wait for seeker to lock on to target.

**Step 4:** Fire the missle when the target is locked.

**▶The Maverick seeker head must be locked on to the target before firing the weapon.**

### 11.205 Using 30mm Cannon

**Step 1:** Visually search for targets.

**Step 2:** Steer the gun pipper over the target. Steady the aircraft controls, flying a stable flight path.

**Step 3:** Fire the cannon.

**▶Maintain a stable flight path while firing the cannon. Any course changes will alter the flight path of the cannon rounds, causing them to miss the target.**

## 11.3 MiG-29A, MiG-29S, Su-27, and Su-33

The MiG-29, Su-27, and Su-33 share common air-to-air weapons procedures. The Su-27, being a dedicated air-to-air platform, does not employ air-to-ground weapons.

### 11.301 Using Air-to-Air Missiles

**Step 1:** For long-range scans, activate the radar and/or EOS as desired. Search for targets using the long-range BVR scan mode. The mode switches to the track-while-scan mode when a target is within tracking range. Alternatively, use the BVR mode to receive target information directly from an AWACS controller.

For short-range scans, activate the radar and/or EOS as desired. Search for targets using the close-air-combat vertical scan or helmet mounted boresight mode.

**Step 2:** Switch modes to the attack single-target-track mode by designating the desired target.

Alternatively, use the helmet-mounted boresight mode. If the radar and EOS are nonfunctional, missiles with IR or active radar seeker heads may use longitudinal missile-aiming mode to acquire targets.

**Step 3:** When the Launch Authorization symbol appears, fire the weapon. The Rejection symbol indicates the target is too close for a safe weapon launch. The Identification Friend or Foe (IFF) symbol indicates the target is friendly.

**▶You must have a target locked and the Launch Authorization symbol visible in the HUD before firing an air-to-air missile.**

### 11.302 Using Iron Bombs (MiG-29, Su-33 only)

**Step 1:** Search for targets either visually or with the air-to-ground radar.

**Step 2:** If using radar, lock the target by slewing the seeker over the target and pressing the Lock button. Maneuver the aircraft to steer the CCIP pipper over the target or the diamond-shaped target designator.

**Step 3:** Steady the aircraft, flying a stable flight path. When the Launch Authorization symbol appears, release the weapon.

**▶ Wait for the Launch Authorization symbol to appear in the HUD before releasing iron bombs. You must stabilize the aircraft before releasing iron bombs. Any pitch, roll, yaw, or airspeed changes will throw the bomb off course.**

### 11.303 Using Air-to-Ground and Anti-ship Missiles (MiG-29, Su-33 only)

**Step 1:** Search for targets with the air-to-ground radar.

**Step 2:** Slew the scan cone over the target and press the Lock key. Next, slew the missile-seeker cross over the target-designator diamond. The missile's view of the target appears in the MFD. Next, fine-tune the missile crosshairs in the MFD and use the Lock key to lock the seeker on the selected target.

**Step 3:** When the Launch Authorization symbol appears, release the weapon. If the autotrack symbol on the left of the HUD flashes, the missile requires continuous guidance from the onboard radar. Do not break the radar lock while the Autotrack symbol flashes, or the missile will be lost.

**▶ Wait for the Launch Authorization symbol to appear in the HUD before firing air-to-ground missiles. Do not break radar lock on the ground target as long as the Autotrack symbol is flashing.**

### 11.304 Using Rockets (MiG-29, Su-33 only)

**Step 1:** Search for targets visually or with the air-to-ground radar. Locking the pod on the target helps locate it in the HUD.

**Step 2:** Steer the aircraft to bring the aiming reticle over the target. Steady the aircraft, flying a stable flight path.

**Step 3:** When the Launch Authorization symbol appears, release the weapon.

**▶ Wait for the Launch Authorization symbol to appear in the HUD before releasing rockets. You must stabilize the aircraft before releasing rockets. Any pitch, roll, yaw, or airspeed changes will throw the rockets off course.**

## 11.4 Su-25

### 11.401 Su-25 Using R-60 Air-to-Air Missiles

**Step 1:** Activate Air-to-Air weapons mode.

**Step 2:** Activate laser-ranger finder.

**Step 3:** Place targeting reticule over target and press the designate key.

**Step 4:** If the target reticule is locked to and following the target, the R-60 seeker has locked to the target.

**Step 5:** Launch the missile.

## 11.402 Using Rockets

**Step 1:** Activate Air-to-Surface weapons mode.

**Step 2:** Select Air-to-Surface rockets.

**Step 3:** Activate laser range finder.

**Step 4:** Place airecraft in shallow dive towards target.

**Step 5:** When aiming reticule is over target, launch rockets.

## 11.403 Using Bombs

**Step 1:** Activate Air-to-Surface weapons mode.

**Step 2:** Select bombs.

**Step 3:** Activate laser range finder.

**Step 4:** Place aircraft in a 30- to 60-degree dive towards target.

**Step 5:** When aiming reticule is over target, drop bombs.

## 11.404 Using Anti-Radar Missile

**Step 1:** Activate Air-to-Surface weapons mode.

**Step 2:** Select anti-radar missile.

**Step 3:** Activate laser range finder.

**Step 4:** Fly towards radar emitter.

**Step 5:** When aiming reticule is over target, launch missiles.

## 11.405 Using Guided Missiles

**Step 1:** Activate Air-to-Surface weapons mode.

**Step 2:** Select guided missile.

**Step 3:** Activate laser range finder.

**Step 4:** Fly towards target.

**Step 5:** Place aiming reticule over target and designate.

**Step 6:** Before or after missile launch, use slew keys to adjust aiming point.

Lock On Design Team

# TECHNICAL SUPPORT

Before contacting Ubisoft's Technical Support department, please first read through this manual and the README file (on the game CD). Also browse through our FAQ listings or search our support database at our website, **http://support.ubi.com.** Here you will find the most recently updated information since the game's release.

Also, please make sure that your computer meets the minimum system requirements, as our Support Representatives will be unable to assist customers whose computers do not meet these criteria.

Whenever you contact the Technical Support Department, please include the following information or have it available if you are calling:

- Complete product title (including version number).
- Exact error message reported (if applicable) and a brief description of the problem you're encountering.
- Operating system.
- Processor speed and manufacturer.
- Amount of RAM.
- Video card that you are using and the amount of RAM it has.
- Type of sound card you are using.
- Maker and speed of your CD-ROM or DVD drive.

**Contact Us over the Internet:** This is the best way to contact us. Our website is open 24 hours a day, 7 days a week, and it contains the most up-to-date Technical Support information available, including patches that can be downloaded free of charge. We update the Support pages on a daily basis, so please check here first for solutions to your problems: **http://support.ubi.com/.**

**Contact Us by Email:** For fastest response via email, please visit our website at: **http://support.ubi.com/.**

From this site, you will be able to enter the Ubisoft Solution Center where you can browse through our listings of Frequently Asked Questions (FAQ), search our database of known problems and solutions, or, for fastest email response, you can send a request for Personal Assistance from a Technical Support Representative. It may take up to 72 hours for us to respond to your email depending upon the volume of messages we receive.

**Contact Us by Phone:** You can also contact us by phone by calling 919-460-9778 (for our customers in Quebec, we provide French language support at 866-824-6515). Please note that this number is for technical assistance only. No hints or tips are given over the Technical Support line. When calling our Technical Support line, please make sure you are in front of your computer and have all of the necessary information listed above on hand. Be advised that our Technical Support Representatives are available to help you Monday–Friday from 9am–9pm EST (French language support is available from 7am–4pm EST). While we do not charge for Technical Support, normal long distance charges apply. To avoid long distance charges, or to contact a Support Representative directly after these hours, please feel free to use one of the other support avenues listed above. Email issues usually receive a response within 2 business days.

**Contact Us by Standard Mail:** If all else fails you can write to us at:

Ubisoft Technical Support, 3200 Gateway Centre Blvd., Suite 100, Morrisville, NC 27560

**Return Policy:** Please do not send any game returns directly to Ubisoft before contacting Technical Support. It is our policy that game returns must be dealt with by the retailer or online site where you purchased the product. If you have a damaged or scratched CD, please visit our FAQ listing for your game and get the latest replacement policy and pricing. We will not accept unsolicited returns/exchanges without prior approval and an RMA (Return Materials Authorization) number from a Support Representative.

# Lock On

# Training Manual

Written by: Mark "Shepski" Shepheard

# Table of Contents

# *Lock On Training Manual: Introduction*

“Welcome to the Lock On training manual.  This manual will provide you with a complete training syllabus covering all aspects of normal and combat operation for the flyable aircraft in the simulation.  This will include system descriptions and step by step operation including the required key presses applicable to Lock On.

This manual covers each of the training missions in the simulation plus several advanced tutorials ranging from intercept tactics to carrier qualifications.  It was my goal in designing this manual to create a syllabus that would be clear and concise yet easy to understand for all flight simulation enthusiasts no matter what level of knowledge or proficiency he or she might have.  This manual does not apply to any of the easy options in Lock On and uses the Russian Symbology for each of the eastern aircraft.  I really hope that you will discover all there is in this simulation by getting to know each and every aircraft available.  There are some real jewels to be found in exploring the eastern and western jets.

I hope this manual will further your enjoyment of this breathtaking flight simulation!”

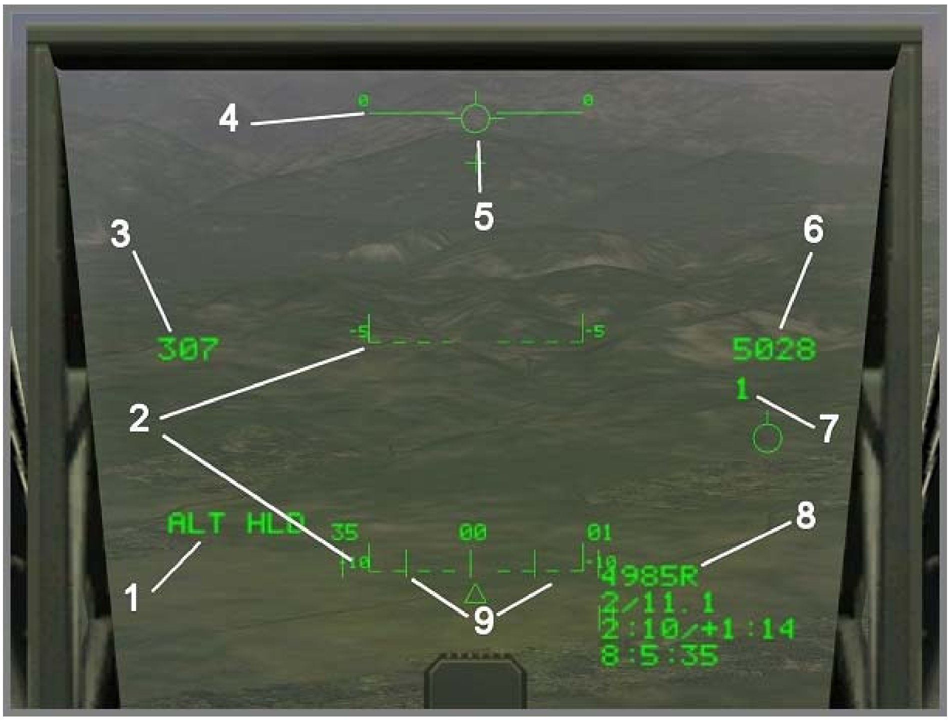
Mark ‘Shepski’ Shepheard

# *Undergraduate Pilot Training - Introduction*

Welcome to Lock On Undergraduate Pilot Training!  This is your introduction to flight training and using the A-10A Thunderbolt II. You will learn the information that the Head Up Display or HUD provides you and how to maneuver the aircraft with pitch, roll, and yaw commands.

### A-10A Head Up Display Overview

The A-10A uses a Head Up Display(HUD) which reflects information onto a vertical piece of glass located on the glare shield in the pilot's line of sight.  The following section will detail the specific elements of the basic HUD.




1. Altitude Hold Indication
2. Pitch Ladder.
3. Digital Airspeed Indicator(ASI).
4. Zero pitch horizon Line.
5. Total Velocity Vector(TVV).
6. Digital Barometric Altimeter.
7. Digital Pitch Indicator.
8. Digital Radar Altimeter.
9. Heading Tape

1. **Total Velocity Vector(TVV):**  Displays the instantaneous flight path of the aircraft at all times.

2. **Pitch Ladder:** Displays the pitch attitude or nose position of the aircraft with reference to the horizon.

3. **Horizon Line:** Is a solid line indicating zero pitch.

4. **Digital Airspeed Indicator(ASI):** Displays the aircraft's airspeed.

5. **Digital Barometric Altimeter:** Displays the aircraft's altitude above mean sea level at all times.

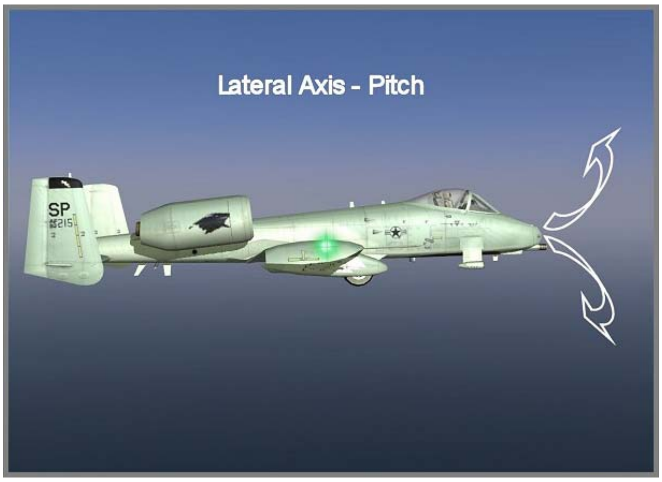
6. **Digital Pitch Indicator:** Displays the pitch of the aircraft with a negative number representing a nose low pitch and a positive number indicating a nose high pitch.

7. **Digital Radar Altimeter:** Displays the altitude above ground with an 'R' after the readout.

8. **Heading Tape and caret:** Displays the aircraft's magnetic heading as a scrolling tape and at the bottom center of the tape is a caret that marks the aircraft's current heading.

### Attitudes and Movements: Pitch, Roll, and Yaw

Maneuvering to specific attitudes is what pilots do to control their aircraft while in flight. For example, making a pitch up movement will create a nose high attitude and will result in a climb if airspeed is sufficient. Rolling the wings will create a bank attitude, yawing the nose will create a skid attitude, and combining both bank and skid attitudes will result in a turn. When maneuvering the aircraft, 3 axis are controlled, the lateral(pitch), the longitudinal(roll), and the vertical(yaw).

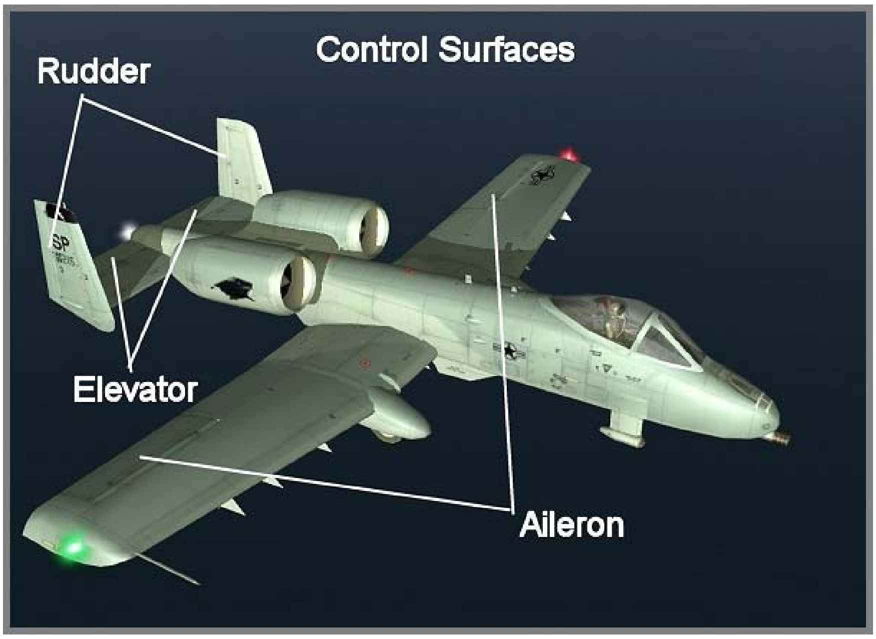





- To change the aircraft pitch (move the nose up or down) the elevator is moved by pulling back or pushing forward on the flight stick or by pressing the 'DOWN ARROW' and 'UP ARROW' keys.

- To roll and bank the aircraft the ailerons are moved by pushing right or left on the flight stick or by pressing the 'LEFT ARROW' and 'RIGHT ARROW' keys.

- To yaw the aircraft and change the lateral the direction the nose is pointing the rudder is moved with the rudder pedals or by pressing the 'Z' and 'X' keys to yaw the nose left and right respectively.




When performing a climb there are 3 elements on the HUD to monitor:

1. Nose high attitude as indicated by the positive pitch ladder and digital pitch indication.
2. Increasing altitude.
3. Decreasing airspeed.

When performing a descent there are 3 elements on the HUD to monitor:

1. Nose low attitude as indicated by the negative pitch ladder and digital pitch indication.
2. Decreasing altitude.
3. Increasing airspeed.

When performing a turn there are 2 elements on the HUD to monitor:

1. Banked pitch ladder.
2. Active heading tape.

## Steep Turn Maneuver

A steep turn is a maneuver requiring good control of the pitch and roll attitudes. It is used in flight tests and check rides for pilots flying all types of aircraft. Learning to master this maneuver is critical when flying high performance combat aircraft. It is a level 360 degree turn in a 60 degree bank with a reversal after the first 180 degrees of direction change.

To Perform a Steep Turn:

1. Begin straight and level flight at **300 knots** and **5000 feet** on a **heading of 360**.
2. Roll the jet to approximately **30 degrees** of right bank and note the slow turn by monitoring the heading tape.
3. Keep increasing bank to **60 degrees** and as the turn rate increases the nose will want to drop due to loss of lift so you must pull back slightly on the stick and add a little thrust to maintain your altitude and airspeed.
4. After passing through **170 degrees** start a roll in the opposite direction back to **60 degrees** of bank.
5. Maintain your bank, altitude, and speed through the turn.
6. After passing through **010 degrees**, roll back to wings level and decease thrust slightly to roll out on the **360 degree heading at 5000 feet and 300 knots.**

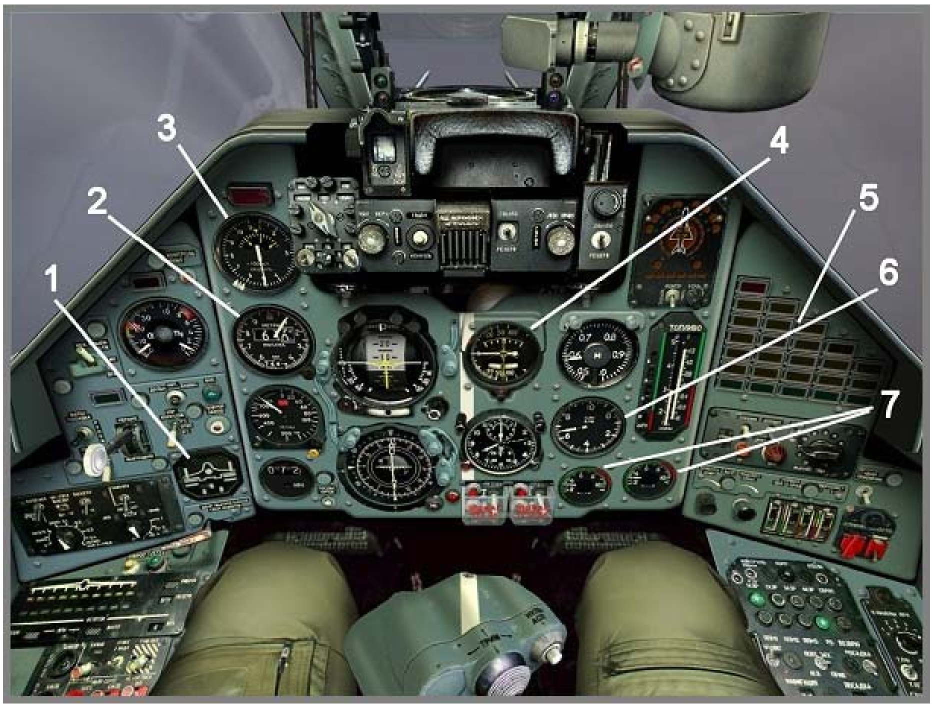
If you can do this steep turn maneuver with a maximum of 200 feet in altitude deviation and 20 knots in airspeed deviation you are doing very well and flying to a high standard.

# Undergraduate Pilot Training – Take Off

Welcome to Taxi and Take Off training in the Sukhoi Su-25 Frogfoot aircraft! The Su-25 is a strong and well-built Russian designed twin turbojet ground attack aircraft and features conventional instruments and systems. In this tutorial you will learn about a few of the instruments required for visual fight and how to use them to start the aircraft, taxi, and conduct a safe take off.

### Su-25 Instruments For Visual Flight

The instruments of the Russian built aircraft are similar to those from the west with a few exceptions, which will be explained later in the training manual. Detailed below are the basic instruments required to start the engines and to operate the aircraft in good weather under visual conditions.




1. Aircraft Configuration Display.
2. Barometric Altimeter.
3. Airspeed Indicator(ASI).
4. Variometer.
5. Systems and Warning Panel.
6. N2 Engine Gas Generator gauge.
7. Exhaust Gas Temperature(EGT).

1. **Airspeed Indicator(ASI):** Displays the aircraft's indicated airspeed in km/h.

2. **Barometric Altimeter:** Displays the aircraft's altitude above mean sea level in meters at all times.

3. **Aircraft Configuration Display:** Displays the position of the landing gear, flaps, speed brakes, and braking parachute.

4. **Variometer:** Indicates the aircraft's rate of climb and turn. The scale ranges from a maximum climb of 200 meters/second to a descent of 200 meters/second. The turn rate scale ranges from 1 to 3 degrees/second to the left and right.

5. **Systems and Warning Panel:** Displays system operation, malfunction, or abnormality.

6. **N2 gas generator RPM:** Displays the engine core speed as a percentage of maximum RPM.

7. **Exhaust Gas Temperature(EGT):** Displays the engine exhaust temperature in degrees Celsius.

## Engine Start Up

1. To start the R-195 turbojet engines we must first have our thrust levers fully back at the idle gate.
2. Turn the NAV lights on with the **'CTRL-L'** keys to notify any ground personnel that you are about to start up.
3. **To start engine #2**, the right engine, press the **'SHIFT-PAGEUP'** keys to activate the automated start sequence and note the start light on the systems and warning panel.  You should hear the engine turbines start to spool up while watching the N2 gauge.
4. **To abort the start** and shut down the engine press the **'SHIFT-PAGEDOWN'** keys.
5. You monitor the start by watching the N2 engine RPM gauge and can see and hear the speed of the engines increasing while at the same time watching the EGT gauge to make sure you don't get a hot start.
6. Once the engine is at idle or 66% N2 with normal EGT temps and you have a stable start.
7. **To start engine #1**, the left engine, press the **'ALT-PAGEUP'** keys to begin the start and monitor the N2 and EGT gauges looking for a stable start.
8. **To abort the start** and shut down the engine press the **'ALT-PAGEDOWN'** keys.
9. Extend the flaps to the take off position by pressing the **'F'** key as indicated on the configuration display.

## Taxi and Take Off

1. Call for taxi clearance by pressing the **'BACKSLASH'** key followed by the **'F6'** and **'F1'** keys.
2. Increase engine thrust with a throttle or by pressing the **'NUMPAD +'** keys and use the **'NUMPAD –'** keys to reduce thrust.
3. Steer the jet with rudder pedals or by pressing the **'Z'** key to turn left and the **'X'** key to turn right.
4. Once in position on the runway threshold, request taxi clearance by pressing the **'BACKSLASH'** key followed by the **'F6'** and **'F2'** keys.
5. Once you have take off clearance, turn on the landing lights by pressing the **'ALT-L'** keys.
6. Hold the wheel brakes by holding down the **'W'** key.
7. Increase thrust to **90% N2** and wait **3 seconds** to ensure the engine is performing correctly.
8. Release the brakes and maintain the runway centerline with the rudder.
9. At **260 km/h, rotate the jet at 3 degrees per second** to begin a climb.
10. At positive rate, indicated on the Variometer, retract the landing gear by pressing the **'G'** key.
11. At **100 meters** above the ground, retract the flaps with the **'F'** key.
12. Continue to climb at **600 km/h.**

# Undergraduate Pilot Training – Stall and Spin Recovery

Welcome to Stall and Spin Recovery training in the A-10A. In this tutorial you will learn how to recognize the signs of an oncoming stall and a developed spin and how to recovery from them if you didn't heed their earliest warnings.

A stall occurs when the angle of attack of a particular wing is increased to its critical angle and the smooth airflow needed for lift is separated from the top of the wing. When this critical angle of attack is reached, the wing will no longer produce lift and the aircraft will fall or break in a nose down attitude. A stall can occur at any speed, power setting, or attitude and can be fatal if a recovery is not possible do to low altitude.

Stall Entry and Recovery

The first stall will be a normal power off stall encountered primarily while on approach to land.

.

Stall

Accelerated Stall

To Enter and Recover from a Normal Stall:

1. Begin from level flight at **5.000 feet** with an airspeed of approximately **200 knots**.
2. Reduce thrust to idle and as the speed bleeds off keep pulling back on the stick to raise the nose to hold your altitude.
3. As the angle of attack increases and the air begins to separate you will hear the sound of the air get louder. As you continue the separating air causes vortices above and off the trailing edge of the wing causing the physical and audible buffet. The closer you get to the critical angle the louder noise and more violent buffet is experienced.
4. To recover, set full thrust and hold the nose in a level attitude until your speed increases and you begin to climb.

The whole point of learning to recognize the symptoms of an impending stall is to recover at the first sign of buffet and to never actually stall.

The second stall will be an accelerated climbing turn stall and one you are most likely to encounter during hard combat maneuvering.

To Enter and Recover from an Accelerated Climbing Turn Stall:

1. Begin from level flight at **5.000 feet** and set **90% N1** and let the speed increase to **350 knots**.
2. Bank hard and begin a climbing turn applying maximum G.
3. As the angle of attack increases much faster, the buffet and stall are much more severe resulting in a wing drop.

4. To recover, level the wings, apply full thrust, and push forward to level the nose.

### Spin Entry and Recovery

A spin is simply, a stall aggravated by yaw. If you stall while in a turn and you don't recover quick enough you will enter a spin.

**To Enter and Recover from a Spin:**

1. Begin from level flight at **10,000 feet** and **200 knots.**
2. Reduce thrust to idle.
3. Continue until the stall buffet is felt.
4. Apply full right rudder.
5. Continue to pull back on the stick and over you go. Wait until a steady rotation develops. You are in a right spin and note that the ADI slip ball is to the left. The ADI is your primary indicator of the direction of the spin
6. To recover, neutralize the flight stick and step on the ball.
7. Apply full left rudder until the rotation beings to stop.
8. As the rotation stops, add full power and push the nose forward to break the stall.
9. As your speed increases, hold a level attitude and then climb away.

Stalls and spins can result in death so avoid them at all costs! If you happen to stall and enter a spin that you can't recover from then EJECT when you reach 3,000 feet or eject immediately once below this altitude. Do not try to recover from a developed spin once below 3,000 feet.
One last important note, if you ever enter an inverted spin, recover by doing the opposite and apply full rudder by stepping on the opposite side of the ball and after rotation stops, pull back on the stick to break the stall.

# Undergraduate Pilot Training – Aileron Roll

Welcome to aileron roll training in the Su-25. An aileron roll is a very basic flight maneuver where you roll the aircraft 360 degrees about its longitudinal axis. The aileron roll is a basic maneuver that will be used with more complex maneuvers such as the Split-S and Immelman, which are next in the training syllabus.

To Perform an Aileron Roll:

1. Begin from level flight at **1000 meters** with an airspeed of approximately **700 km/h** and heading **270 degrees**.
2. Pull back slightly on the stick to raise the nose to about **8 degrees of pitch** then center the stick and push it smoothly left to full deflection.
3. As the aircraft rolls inverted the nose will fall back to the horizon then stop the roll with right stick deflection and return the aircraft back to wings level.

If performed properly the aircraft should hardly deviate from its original heading and altitude.

# Undergraduate Pilot Training – Split-S and Immelman

Welcome to Split-S and Immelman training in the A-10A. The Immelman and the Split-S are both simple but effective tactical maneuvers that allow you to reverse your direction of flight by 180 degrees. These time-honored maneuvers developed back in World War I still remain useful today.

A Split-S, which trades altitude for airspeed, is an effective means to disengage from a fight.

To Perform a Split-S:

1. Roll the aircraft inverted and pull back on the stick to start a dive.
2. Reduce thrust to idle to prevent overspeeding the airframe.
3. Maintain back pressure as the aircraft continues to dive and as you bring the nose back up to the horizon, center the stick to return to straight and level flight.

An Immelman maneuver, named after WWI ace Max Immelman, trades airspeed for altitude and is useful in 'boom and zoom' attacks.

To Perform an Immelman:

1. Push the thrust levers to full power.
2. From straight and level flight and an airspeed of **330 knots or better**, pull back on the stick to start a climb.
3. Continue to pull back on the stick and after passing through the vertical, when the pitch indicator reads +10 degrees, I roll the aircraft 180 degrees upright and continue flying away straight and level.

# Undergraduate Pilot Training – Barrel Roll

Welcome to Barrel Roll training in the Su-27. A Barrel Roll simply put, is a half roll above the horizon and a half roll below the horizon while maintaining constant G loading on the aircraft and can be both offensive and defensive in nature.

The primary goal of a Barrel Roll is to lengthen the straight-line distance you cover in a given amount of time by adding lateral movement and drag with G loading. If someone is closing fast from your rear, this maneuver can force him to overshoot. If you are closing in too quickly on your target's rear, this maneuver can help to keep you on his tail.
To Perform an Barrel Roll:

1. Begin from level flight at **1000 meters** with an airspeed of approximately **700 km/h** and heading **270 degrees**.
2. Roll **45 degrees** right and begin a shallow climb. This provides the lateral movement you need to begin the roll.
3. Roll back in the opposite direction.
4. Pull back on the stick to maintain maximum G's and complete the first half of the roll with the nose above the horizon.
5. Pull through the horizon to complete the last half with the nose below the horizon and keep pulling to bring the nose back to the horizon as you bring the aircraft to wings level.

A well executed barrel roll will leave you in a solid position behind an aircraft by drastically reducing your closure speed.

# Undergraduate Pilot Training – Visual Landing

Welcome to Visual Landing training in the Su-25. A visual landing is one where there is good forward visibility and no cloud or fog between you and the airport. Primarily you fly the aircraft looking outside while keeping an eye on your altitude, airspeed, and vertical descent rate on the main instrument panel.

From an initial speed of 500 km/h with no external stores and approximately 20 km from the runway with a Su-25 loaded with 50% fuel and no external stores giving a weight of 11,000 kg, the following speeds and thrust settings are applicable for an approach and landing.

**To Perform a Visual Landing:**

1. Reduce power to idle thrust then extend the airbrakes with the '**B**' key.
2. When your speed slows to **400 km/h**, retract the speed brake and extend the flaps to the approach position with the '**F**' key. The flaps will cause the nose to pitch up slightly due to the increase in lift so be ready for it.
3. Slowly bleed off your speed to approximately **350 km/h** and lower the landing gear with the 'G' key indicated down and locked by the 3 green gear lights on the aircraft configuration display.
4. Turn on the landing lights by pressing the '**ALT-L**' keys two times and increase thrust to about **79% N2**
5. You want to maintain this profile of a **79% N2** thrust setting giving a **350 km/h** airspeed and a **5 meter/second** descent rate.
6. When you can see the runway threshold slide just past the base of the canopy frame, start a 30 degree banked turn to final.
7. As you roll onto final, lower the flaps to the landing flap setting with the '**SHIFT-F**' keys and adjust the thrust to about **75% N2** to keep the speed slowly decreasing to about **300 km/h**.

8. After you configure the aircraft for landing and have adjusted the trim you want to monitor your speed and descent angle to the runway.

   The easiest way to keep a good glide path to the touchdown point is to keep the runway threshold stationary on the weapon sighting glass or HUD and if it is kept there you will glide right to it.  This is called a **stabilized approach.**

   If the threshold starts to slide down the glass or HUD it means you are getting high and must increase the descent rate by reducing power and or pitch.  If it slides up, you are low and must increase power and or pitch.

9. Confirm 3 green and landing flaps on the configuration display.
10. As you approach the runway you want to slow to a speed of about **250 km/h** over the threshold and then smoothly pull the thrust levers to idle and slowly raise the nose letting the main gear settle onto the runway in the flare.
11. As the mains touch down extend the speed brakes with the '**B**' key and as the nose wheel touches down deploy the braking parachutes with the '**P**' key and apply the wheel brakes with the '**W**' key.
12. Slow to a safe taxi speed and clean up the aircraft by retracting the speed brakes and raising the flaps.

One important thing to remember about approach and landing speeds is that as the weight of the jet increases, you must increase your speeds and as the weight decreases, you decrease your speeds.

Training Manual 147

# A-10A Introduction and Enroute Navigation Training

Welcome to Enroute Navigation training for the A-10A. In this tutorial you will learn, in detail, about the navigation information displayed on the HUD and on the panel instruments to navigate a series of steerpoints. Learning how to navigate is one of the most important skills a pilot must master. Since you are already familiar with this aircraft after completing the UPT course I won't go into detail about the basic HUD symbology.

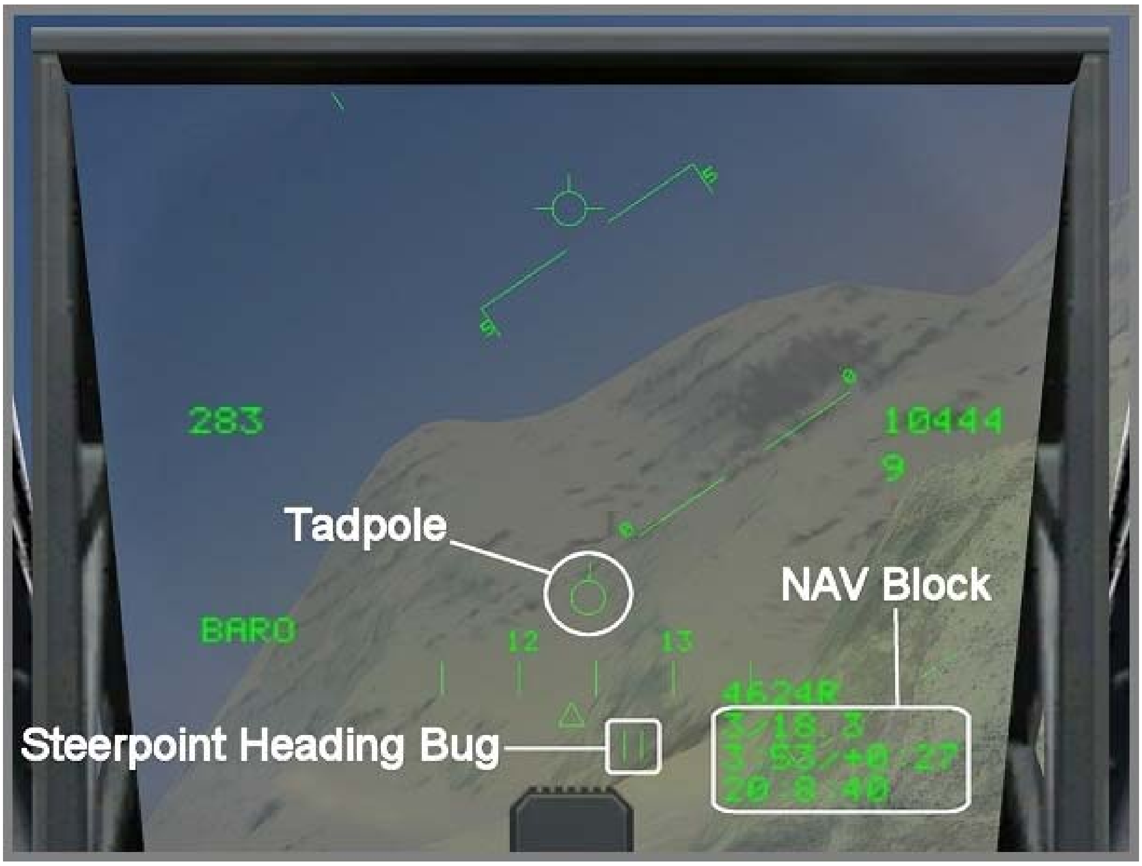
The A-10A is powered by twin tail mounted General Electric TF34-100 high by-pass turbofan engines each rated at 9065 lb. of thrust and is capable of reaching 390 knots at sea level with an 800 nautical mile range and a 45,000 foot ceiling. The A-10 was designed around 'the gun' as a strong and stable weapons platform and has proved it's value over the battlefield throughout many recent conflicts.

The A-10A uses conventional instruments for all facets of operation and navigation. Combat sensors and weapons management are shown on 2 displays consisting of a Television Monitor(TVM) and an Armament Control Panel(ACP).

It is a good idea to go over the flightplan of your mission before starting and write down the required course, altitude, and speed for each steerpoint. You can enter this information on the flightplan document included at the end of this manual in the 'Pilot Reference' section.

When you start the flight and enter the cockpit you will automatically be in the enroute navigation mode.

HUD Navigation Symbology




On the HUD there are 3 NAV items displayed, the 'Tadpole', the steerpoint heading bug, and a NAV block displaying steerpoint information.

- The tadpole will help guide you to the selected steerpoint by moving side to side on the HUD as well as pointing in the direction of the selected steerpoint. For example, if you are left of the steerpoint, the tadpole will be offset to the right of the HUD and its pointer pointing to the right. If the steerpoint is directly ahead of you the tadpole will be centered on the HUD and it will point up to it.

- The steerpoint heading bug is the small '| |' symbol under the heading tape and when aligned with the heading caret you are heading towards the selected steerpoint.
- On the lower right of the HUD is the Navigation block. This block provides all the steerpoint information while in NAV mode. The navigation information is displayed on 3 lines
- The first line displaying the currently selected steerpoint and current distance remaining to the steerpoint.
- The second line displays the actual time remaining to reach the steerpoint and the DELTA (difference in time to reach it as compared to the pre-planned time over the steerpoint). This time will change as your speed differs from the pre-planned speed in the mission editor.
- The third line displays a mission clock indicating real time for the mission.


The 5 basic flight instruments that are required to keep the aircraft in control when you can't see anything outside the canopy are the following:

1. **Attitude Direction Indicator(ADI):** It is an artificial horizon that displays the aircraft’s pitch and bank angles.

2. **Horizontal Situation Indicator(HSI):** Displays a horizontal, top-down view of the aircraft superimposed on a compass. The compass rotates so that the aircraft heading always appears at the top of the display.

3. **Airspeed Indicator(ASI):** Displays indicated airspeed(IAS) from 50 to 500 knots.

4. **Barometric Altimeter:** Displays the aircraft's altitude above mean sea level at all times with a digital window and a sweeping pointer. The altimeter scale reads in 20 foot increments and each whole number represents 100 feet.

5. **Vertical Velocity Indicator(VVI):** Displays the aircraft’s rate of climb or descent in thousands of feet per minute. The needle counts clockwise from zero as the aircraft climbs, and counts counter-clockwise as the aircraft descends.

You can cycle the steerpoints by pressing the **‘TILDE~’** key.

### Attitude Direction Indicator(ADI) – Integrated Flight Director

- Pitch markings are graduated in 5 degree increments with the black half showing a descent and the grey half showing a climb.  The bank markings are graduated in 10-degree increments to 30 degrees then one mark at 60 degrees.
- Integrated into the ADI is an ILS flight director which gives you lateral and vertical guidance for the Instrument Landing System(ILS) at each airport.  The flight director on the ADI is a very precise instrument that will help keep you on the localizer and glideslope.
- The white tic mark on the left side of the ADI is the glideslope deviation caret displaying vertical guidance for the ILS.
- The white tic mark on the bottom is the localizer deviation caret displaying lateral guidance for the ILS.
- The horizon pitch indicator will show your pitch attitude, and the flight director cross in the center of the ADI gives you the direction to maneuver the aircraft to keep it on the ILS.  If you keep both bars crossed at the center, and the two white tick marks centered you will be precisely on the localizer and glideslope.

### Horizontal Situation Indicator (HSI)

- The white needle and tail on the outer edge of the compass ring is the steerpoint-bearing needle and points to the selected steerpoint.
- The digital number on the upper left shows the distance to the steerpoint while the digital number on the upper right shows the required course to the steerpoint.
- The CDI/track bar or Course Deviation Indicator in the center of the HSI illustrates the intended course relative to the aircraft in the center of the instrument.  When the track bar is centered and pointing up, you are on course.

The HSI is the primary navigation instrument and the following section will detail its functionality.

**On course:** When on course the steerpoint bearing needle and the CDI will be aligned and pointing straight up.

**Course to the left:** When the required course between steerpoints is to the left, the bearing needle will be pointing to the left and the CDI will be offset to the left.

**Course to the right:** When the required course between steerpoints is to the right, the bearing needle will be pointing to the right and the CDI will be offset to the right.

To get on course you will have to intercept the required course and then turn to its heading.  Intercepts are normally at 30 and 45 degrees.  The CDI will be displaced to the side that the flight planned course is on and your intercept heading should always be to that side so always take the intercept heading off of that side of the HSI compass.

For example: You are flying on a course of 180 degrees to a steerpoint.  You reach the steerpoint and the NAV computer automatically switches to the new course required to get to the next steerpoint of 130 degrees at 25 miles but you continue straight ahead on a 180 degree heading.

The Displayed NAV information will be the following:

- The HUD NAV block will indicate the next steerpoint, 2 for example, and the distance to reach it, '2/23'.
- The HUD Tadpole will be on the left side of the HUD and pointing left to about 10 o'clock.
- The HUD heading bug will be on the left side of the heading tape.
- The HSI CDI is offset to the left and indicating a course of '130' at the head of the needle and on the display.
- The HSI steerpoint-bearing needle will be pointing left of the CDI head.


To intercept the course of 130 degrees at a 30 degree intercept you find you intercept heading by subtracting the angle from the course, 130-30=100, so the intercept heading will be 100 degrees. Fly a heading of 100 degrees until the CDI is almost centered then turn right to the course heading of 130.

Once on course the Displayed NAV information will be the following:

- The HUD Tadpole will be centered on the HUD and pointing straight up.
- The HUD heading bug will be centered on the caret of heading tape indicating 130.
- The HSI steerpoint-bearing needle will be pointing straight up indicating 130.
- The HSI CDI will be centered and pointing straight up indicating 130 degrees.

If the new course was to the right and the CDI, bearing needle, Tadpole, and heading bug were offset to the right you would add the intercept heading to the course. For example, the new course is 270 and you want to intercept at a 45-degree angle. You would add the angle to the course, 270+45=315. Fly a heading of 315 until the CDI is almost centered then turn left to 270 and you are on course.

A fast and easy method to navigate to a steerpoint is to simply turn the aircraft to a heading where the bearing needle and the tadpole are pointing straight up and the heading bug is centered on the heading caret, then fly to it. You won't be on the flight planned course but you'll get there faster.

It is critical to be able to navigate properly, especially while flying in mountainous areas, which is why this training is so important. Being off course by only a few degrees or missing required altitudes can result in catastrophic consequences.

# *A-10A Gun and Rocket Training*

Welcome to Cannon and Unguided Rockets Training for the A-10A. In this tutorial you will learn to use the General Electric GAU-8A Avenger cannon and Hydra 2.75 inch unguided rockets.

The **GAU-8A Avenger** is easily the most well known weapon in the A-10's arsenal. This huge 30mm 7 barrel rotary cannon has a maximum firing rate of 4,200 rounds per minute and each barrel fires a maximum of 10 rounds per second.

Its ammunition drum holds 1,350 rounds. The load consists of 5 API (Armour Piercing Incendiary) rounds to 1 HEI (High Explosive Incendiary) round in sequence jokingly called a 'Party Mix' by USAF servicemen.

The GAU-8A's accuracy is rated at 5 mil, 80%. This means that 80% of the rounds fired at a slant range of 6000 feet will hit within a circle of a diameter of 30 feet. "The GAU-8A is not a shotgun, it's a laser so exact aiming is required!!", as quoted by Andy Bush.

The diagram below is the A-10A HUD in the CCIP gun mode. Each tick mark around the outside of the pipper circle represents 3000 feet of slant range. The range to the impact is shown by the range clock inside the centre of the circle. You can also see the slant range below the pipper in nautical miles and on the bottom left of the HUD displayed in meters.


You can change the firing rate of the gun with the **'SHIFT-C'** keys to toggle between 30 rounds per second and 60 rounds per second.

**To use the GAU-8A Avenger:**

1. Select the GAU-8A cannon by pressing **'7'**, the air-to-ground weapons key.
2. Press the **'C'** key to switch to the cannon bringing up the Continuously Computed Impact Point(CCIP) gun pipper.
3. Maneuver the jet to place the CCIP gun pipper on the target.
4. Press the **'SPACEBAR'** key to fire the gun when in range.

The most effective attack profile for the A-10A is a LOW-HIGH-LOW profile.  Ingress to the target area at a low level using the terrain to mask your position. Follow this with a pop up to acquire and engage the target.  Then dive back down and egress in a low level, high-speed escape maneuver while deploying expendable countermeasures.

**Hydra 2.75 inch unguided rockets** have a high explosive warhead used for anti-materiel, anti-personnel, and suppression missions.  They are contained in LAU-61 launchers.  The only rockets the A-10A can employ are Hydra high explosive and 'Willie Pete' white phosphorus smoke marking rockets.

**To use Hydra unguided rockets:**

1. Select the Hydra rockets by pressing **'7'**, the air-to-ground weapons key.
2. Press the **'D'** key to cycle the weapon stations until the **'RKT/'** and the rocket CCIP pipper are displayed on the HUD and the LAU-61 stations are active on the ACP with a bottom green lights.
3. Maneuver the jet to place the CCIP rocket pipper on the target.
4. Press the **'SPACEBAR'** key to launch the rockets when in range.


Armament Control Panel(ACP)

The CCIP rocket pipper is identical to the gun pipper with the exception of the "RKT" label as seen below.

Training Manual 153

# A-10A Unguided Bomb Training

Welcome to Unguided Bomb Training for the A-10A. In this tutorial you will learn how to release unguided free-fall iron bombs using different methods and settings. The A-10A is capable of employing 3 different unguided bombs. They are the Mk-84 and Mk-82 Low Drag General Purpose (LDGP) explosive bombs, and Mk-20 Rockeye cluster bombs.

The Mk-84 LDGP 2000 pound bombs can be used against a variety of targets such as hangers, buildings, bunkers, and soft skinned and armoured vehicles of all types. The Mk-82 LDGP is a 500 pound bomb and can be used against all soft skinned and armoured vehicles, small buildings and other installations. The Mk-20 ‘Rockeye’ is a cluster weapon using a clamshell dispenser containing many smaller bomblets that are released above the target and spread out for maximum effect before detonating downward. The Rockeye is effective against all soft skinned and armoured vehicles as well as personnel on the battlefield.

## Bomb Release Modes

The A-10A has 4 bomb release modes:

1. **‘SGL’ or single:** single munitions are released from the selected station.
2. **‘PRS’ or Pairs:** two munitions are simultaneously released from pylons loaded with identical stores.
3. **‘RIP PRS’ or Ripple Pairs:** munitions ripple in pairs from pylons with the same type of stores.
4. **‘RIP SGL’ or Ripple Single:** single munitions ripple from selected stations.

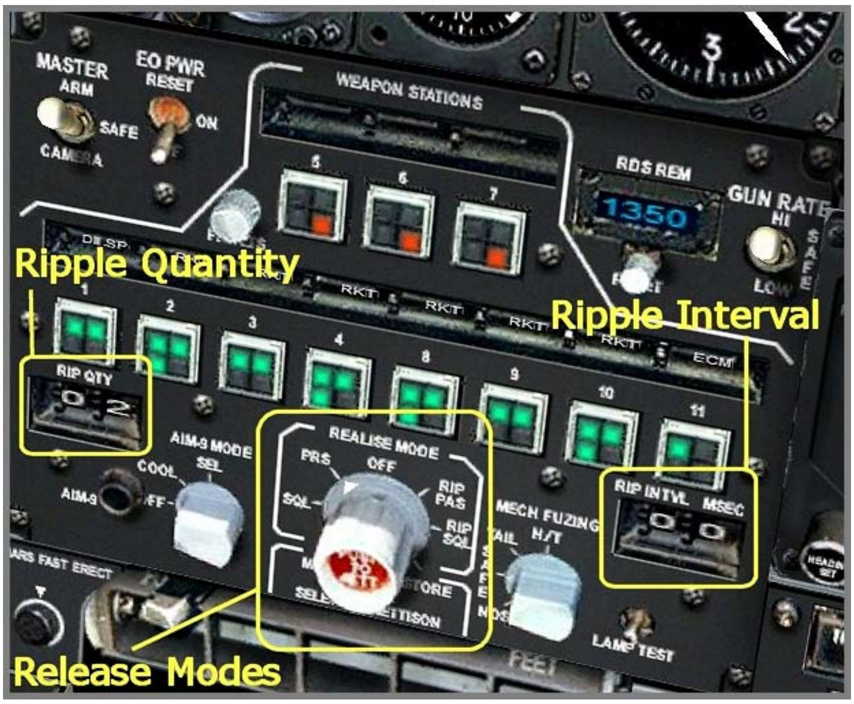
Ripple quantity and ripple interval settings affect the **‘RIP’** modes only.

You can cycle the bomb release modes by pressing the **‘SHIFT-SPACEBAR’** keys. The change is indicated on the ACP.

## Bomb Release Quantity and Interval Settings

The ripple quantity and ripple interval for iron bombs can be altered. The ripple quantity determines how many iron bombs or cluster bombs will be released when the weapon release button is pressed once. You alter this with the '**CTRL-SPACEBAR**' keys. Each press of this key combination increases the count by one. The bomb release quantity can be adjusted from 2 to 12 bombs and is indicated on the ACP.

The ripple interval is the time, in milliseconds, between the release of each bomb if the ripple quantity is greater than 1. Each press of the '**V**' key increases this interval by 1 millisecond. Pressing the '**SHIFT-V**' keys will cycle the interval backwards. The bomb release interval can be adjusted from 1 to 99 milliseconds and is indicated on the ACP.

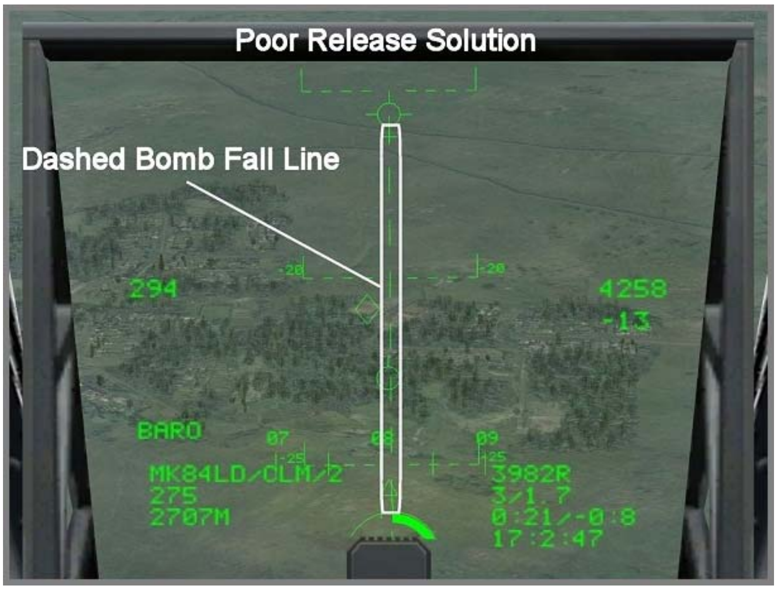


To use Unguided Bombs in 'SGL' and 'PRS' modes:

1. Select the air to ground weapon mode by pressing the **'7'** key.
2. Press the **'D'** key to cycle the weapon stations until the bomb you want to drop is indicated on the HUD.
3. Press the **'SHIFT-SPACEBAR'** keys to select either **'SGL'** or **'PRS'** release mode.
4. Maneuver the jet to place the CCIP unguided bomb pipper on the target.
5. Press the **'SPACEBAR'** key to release the bombs when the CCIP pipper is on the target and the bomb fall line has changed from a dashed line to a solid line on the HUD.

To use Unguided Bombs in 'RIP SGL' and 'RIP PRS' modes:

1. Select the air to ground weapon mode by pressing the **'7'** key.
2. Press the **'D'** key to cycle the weapon stations until the bomb you want to drop is indicated on the HUD.
3. Press the **'SHIFT-SPACEBAR'** keys to select either **'RIP SGL'** or **'RIP PRS'** release mode.
4. Press the '**CTRL-SPACEBAR**' keys to select the quantity of bombs you want to release.
5. Press the '**V**' or '**SHIFT-V**' keys to set the release interval.
6. Maneuver the jet to place the CCIP unguided bomb pipper on the target.
7. Press the **'SPACEBAR'** key once to ripple the bombs when the CCIP pipper is on the target and the bomb fall line has changed from a dashed line to a solid line on the HUD.




# A-10A Maverick Tactical Missile Training

Welcome to Air to Ground Tactical Missile training for the A-10A. In this tutorial you will learn how to use the AGM-65 Maverick air to ground tactical missiles. The A-10A is capable of employing two different types of Maverick missiles, the AGM-65K optical and the AGM-65D infrared guided missile.

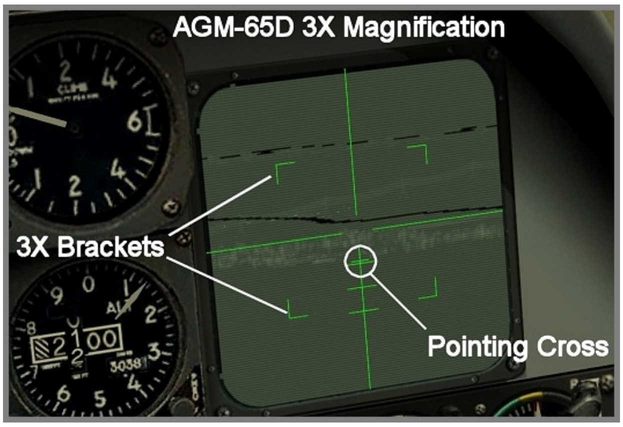
The Hughes AGM-65 Maverick series of tactical guided missiles are stand off missiles which will help keep you out of range of the most serious threats on the battlefield, radar guided Anti Aircraft Artillery(AAA) and short range Surface to Air Missiles(SAM). The AGM-65 Maverick is designed for attacks against hardened targets like buildings and any type of vehicle including soft skinned vehicles and tanks. The Maverick seeker image is displayed on the cockpit Television Monitor(TVM) and is magnified for easier identification and locking of a target.

The long range AGM-65D uses an infrared seeker, which is best for night operations and poor weather conditions and uses the heat signature of a target to lock on to. The AGM-65D has 2 levels of magnification, 3X(built in) and 6X with a maximum range of 6 nautical miles. The shorter range AGM-65K uses an optical seeker and requires day visual conditions. The AGM-65K has a built in 3X-magnification level only with a maximum range of 3 nautical miles.

When a Maverick is selected, displayed on the middle of the HUD is the Maverick search pipper, which can be moved using the '**PERIOD(.)**', '**SEMI-COLON(;)**', '**COMMA(,)**', and '**FORWARD SLASH(/)**' keys to slew the pointing cross up, down, left, or right respectively. Below the pipper is the slant range to the ground. On the lower left of the HUD a '/' will indicate how many missiles are onboard. When the seeker has locked onto a target the pipper will turn into a wagon wheel with a cross in the center.


The Armament Control Panel(ACP) shows that the AGM-65 is loaded on a station by an 'EO' label.

The image displayed on the TVM has a tracking gate, a range scale, and a pointing cross. The seeker must be uncaged to allow it to lock onto the object closest to the tracking gate. Once it is locked on the TVM will show the gate surrounding the locked target. The gate will remain ground stabilized once locked on and the seeker will track the target as it moves. When the AGM-65D is used there will be 4 brackets on the display indicating a 3X-magnification level and when the magnification is set to 6X, the brackets will disappear. The pointing cross always indicates the position of the aircrafts' nose as opposed to where the seeker is looking.



**To use the AGM-65D Infrared Guided Tactical Missile:**

1. Select the air to ground weapon mode by pressing the **'7'** key.
2. Press the '**D**' key to cycle stations to bring up the AGM-65D as indicated on the HUD by the by the pipper and the infrared image displayed on the TVM.
3. Slew the targeting cross over the target area with the '**PERIOD(.)**', '**SEMI-COLON(;)**', '**COMMA(,)**', and '**FORWARD SLASH(/)**' keys.
4. If required, zoom to the **6X** magnification level by pressing the **'='** key and the **'-'** key to revert back to **3X.**
5. Press the **'TAB'** key to uncage the seeker and allow it to lock onto the nearest target.
6. Press the **'SPACEBAR'** key to fire the missile when in range as indicated by a flashing cross on the TVM.

**To use the AGM-65K Optically Guided Tactical Missile:**

1. Select the air to ground weapon mode by pressing the **'7'** key.
2. Press the '**D**' key to cycle stations to bring up the AGM-65K as indicated on the HUD by the by the pipper and the optical image displayed on the TVM.
3. Slew the pipper over the target area with the '**PERIOD(.)**', '**SEMI-COLON(;)**', '**COMMA(,)**', **and** '**FORWARD SLASH(/)**' keys.
4. Press the **'TAB'** key to uncage the seeker and allow it to lock onto the nearest target.
5. Slew the gate with the '**PERIOD(.)**', '**SEMI-COLON(;)**', '**COMMA(,)**', and '**FORWARD SLASH(/)**' keys. if required.
6. Press the **'SPACEBAR'** key to fire the missile when in range as indicated by a flashing cross on the TVM.

# *A-10A AIM-9 Air To Air Missile Training*

Welcome to AIM-9 Sidewinder training for the A-10A. In this tutorial you will learn how to employ the AIM-9M infrared heat seeking air to air missile against airborne targets. The AIM-9 is considered a 'self defense' weapon when on the A-10A.

The Raytheon AIM-9 Sidewinder is a fire and forget short-range heat seeking all aspect supersonic air to air missile. Because the A-10 has no air-to-air radar to help acquire targets you will be depending on your Mark-1 eyeball to both locate and align the AIM-9 seeker on the target.

Once the AIM-9 is uncaged, the HUD displays a circle, which is the seeker Field of Regard(FOR), and indicates the limits of Sidewinder's seeker head. You must place your intended target within that circle in order to attain a lock. There is also a growling aural indication of the scanning seeker. When the infrared seeker finds and locks onto a target, the Field of Regard circle will collapse on the target and begin to flash. The growling tone will change to a high pitched tone when a good lock is established.



To use AIM-9M Sidewinder Missiles:

1. Uncage the AIM-9M by pressing the **'6'** key as noted by the AIM-9 HUD and the growling tone.
2. Maneuver the jet to place the target within the Field of Regard circle(FOR).
3. Wait for the seeker to lock on indicated by a collapsing and flashing FOR circle and a high pitched tone.
4. Press the **'SPACEBAR'** key to fire the missile.

# *F-15C Introduction and Enroute Navigation Training*

Welcome to Enroute Navigation training for the F-15C. In this tutorial you will learn about the navigation information displayed on the HUD. The navigation information on the instrument panel is identical to that of the A-10A so that aspect won't be covered here.

The legendary F-15C Eagle is an all weather day/night air superiority fighter aircraft. It is also one of the world's most successful fighter aircraft with an unmatched combat record in modern times.

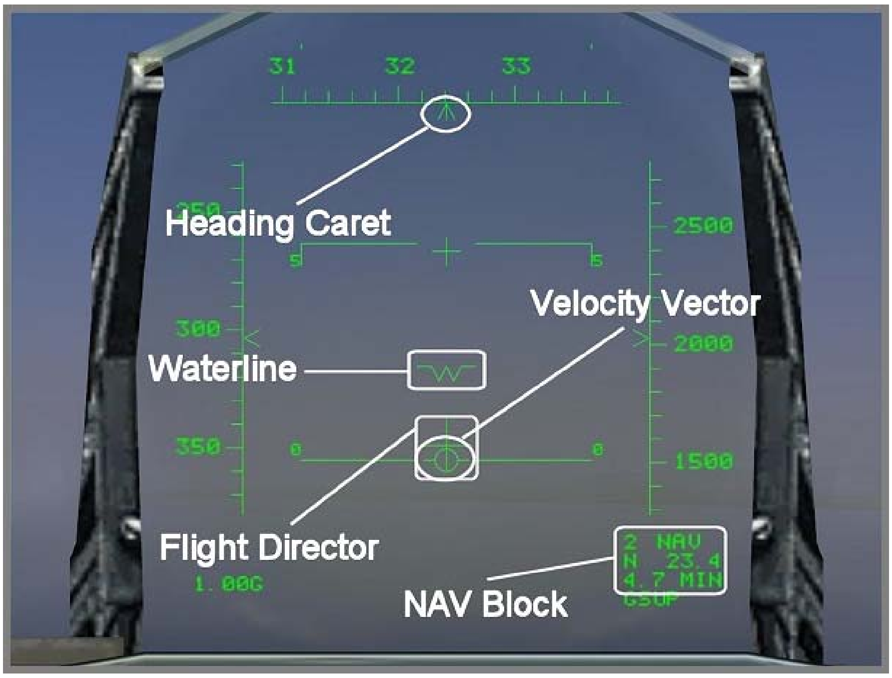
The F-15C is powered by twin Pratt and Whitney PW-220 afterburning turbofan engines each rated at 23,830 pounds of static thrust capable of reaching speeds in excess of 1,400 knots and Mach 2.5 with a service ceiling of 60,000 feet

The F-15C uses conventional instruments for flight, navigation, and standard aircraft systems. Combat sensors and weapons management are displayed on 3 displays consisting of a Vertical Situation Display(VSD), Tactical Electronic Warfare System(TEWS), and a Programmable Armament Control Set(PACS).

It is a good idea to go over the flightplan of your mission before starting and write down the required course, altitude, and speed for each steerpoint. You can enter this information on the flightplan document included at the end of this manual in the 'check list and key reference' section.

When you start a flight and enter the cockpit you will automatically be in the enroute navigation mode.

HUD Navigation Symbology




On the HUD there are 3 NAV items displayed, the Flight Director, the steerpoint heading bug, and a NAV block displaying steerpoint information.

- In the center of the HUD there is a 'W' shaped symbol which is the waterline and it represents the longitudinal axis of the aircraft at all times or the exact spot the nose is pointing. The distance between the waterline. The Velocity Vector is the aircraft's angle of attack.
- The Integrated Flight Director provides pitch and steering guidance. To use the flight director just maneuver the aircraft to keep the director cross in the center of the HUD.
- The heading tape is on the top of the HUD with the small inverted 'V', caret, showing current heading and the small vertical line is the heading bug.

- On the lower right of the HUD is the Navigation block. This block provides all the steerpoint information while in NAV mode. The navigation information is displayed on 3 lines, the first line displaying the Navigation mode and the currently selected steerpoint.
- The second line displays the current distance remaining to the steerpoint.
- The third line displays the actual time remaining to reach the steerpoint and the DELTA or difference in time to reach it as compared to the pre-planned time over the steerpoint. This time will change as your speed differs from the pre-planned speed in the mission editor
- The third line displays a mission clock indicating real time for the mission.

The 5 basic flight instruments in the F-15C are identical to the A-10A with the exception of a Mach scale on the airspeed indicator.

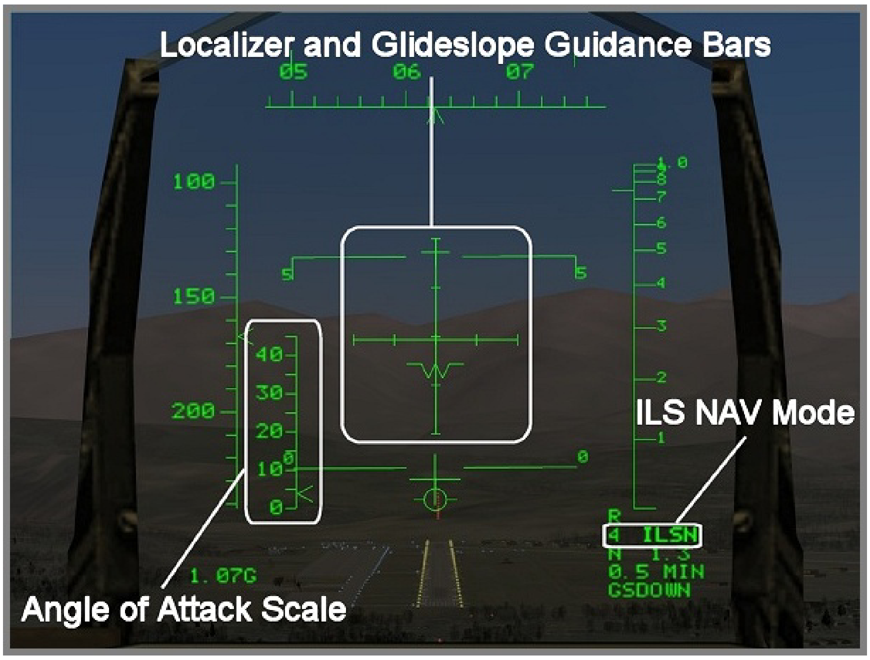
# F-15C Instrument Approach Training

Welcome to Instrument Approach training for the F-15C. In this tutorial you will learn about the information displayed on the HUD to conduct an instrument approach to landing required when the weather is poor or the cloud bases are low. Instrument flying is another skill that must be mastered in order to bring your jet back to the earth safely in all conditions.

When you start a flight and enter the cockpit you will automatically be in the enroute navigation mode.
.

F-15C ILS HUD Symbology

The additional HUD symbology displayed in the ILS approach mode is detailed below.




1. **Localizer and glideslope guidance bars:** Displays the deviation from the localizer and glideslope.

2. **Angle of Attack(AoA) scale:** Displays the angle of attack of the jet in units.

3. **ILS NAV mode indication.**

The navigation instruments on the panel are identical to the A-10A with the exception of a Mach scale on the airspeed indicator.

The aircraft in Lock On have 4 different navigation modes as detailed below. The navigation modes can be cycled with the **'1'** key.

1. **Basic free flight mode:** Displays no navigation information and is used for free flight and practicing flight maneuvers.

2. **Enroute navigation mode:** Displays steerpoint navigation information on the HUD, ADI, and HSI.

3. **Return navigation mode:** Displays navigation information to the Initial Approach Fix(IAF), which will set you up for an approach and landing at an airport.

4. **ILS navigation mode(ILSN):** Displays navigation information to the Final Approach Fix(FAF) followed by the Instrument Landing System(ILS) information to an airport.

You can cycle the steerpoints and airport IAFs and FAFs by pressing the **'TILDE~'** key.

### Instrument Flight Navigation to the IAF

1. Press the **'1'** key to cycle navigation modes until IAF steerpoint appears in the NAV block on the HUD.
2. Turn the jet so the HUD flight director is centered and the steerpoint bearing needle is pointing up. This will give you a direct route to the IAF.
3. Climb or descend as required by the steerpoint altitude information on the top right of the HUD.
4. **5 miles** from the IAF you should be slowed to about **200 knots**. Extend the flaps by pressing the **'F'** key.
5. Continue to the IAF and the NAV computer will automatically select the ILS mode when you are within range.

### Instrument Flight Navigation to the FAF

1. Press the **'1'** key to cycle navigation modes until **'ILSN'** appears in the NAV block on the HUD.
2. Turn the jet so the HUD flight director is centered and the steerpoint bearing needle is pointing up. This will give you a direct route to the FAF.
3. Climb or descend as required by the altitudes in the flightplan.
4. **2 miles** from the FAF you should be slowed to about **180 knots** with the flaps extended.

### Instrument Landing System(ILS) Approach and Landing

1. At this point in the approach you will be in the ILS mode as indicated by the **'ILSN'**.
2. At glideslope intercept extend the landing gear by pressing the **'G'** key and turn on the landing lights with 2 presses of the **'ALT-L'** keys.
3. Increase thrust to about **80% N1** to maintain **150 knots**. Confirm 3 Green and flaps set.
4. Keep the ILS localizer and glideslope bars crossed in the center of the HUD by maneuvering to keep the flight director centered. Confirm with the ADI flight director and the HSI ILS guidance bars.
5. Maintain a **900 feet/minute** descent rate and **150 knots** down the glideslope.
6. Once visual and on short final, slowly reduce speed to cross the threshold at **130 knots** and flare to the landing.

While on an ILS it is imperative to make very small corrections and thrust changes to maintain a stabilized approach.

### Missed Approach

In the event you do not see the runway you must execute a missed approach.

1. Pitch nose up to **10 degrees**.
2. Set maximum thrust with afterburner.
3. At positive rate on the vertical velocity indicator, raise the landing gear.
4. Once the gear is up, raise the flaps.
5. Continue climb to at least **3000 feet** above ground and then turn on course to your alternate airport.

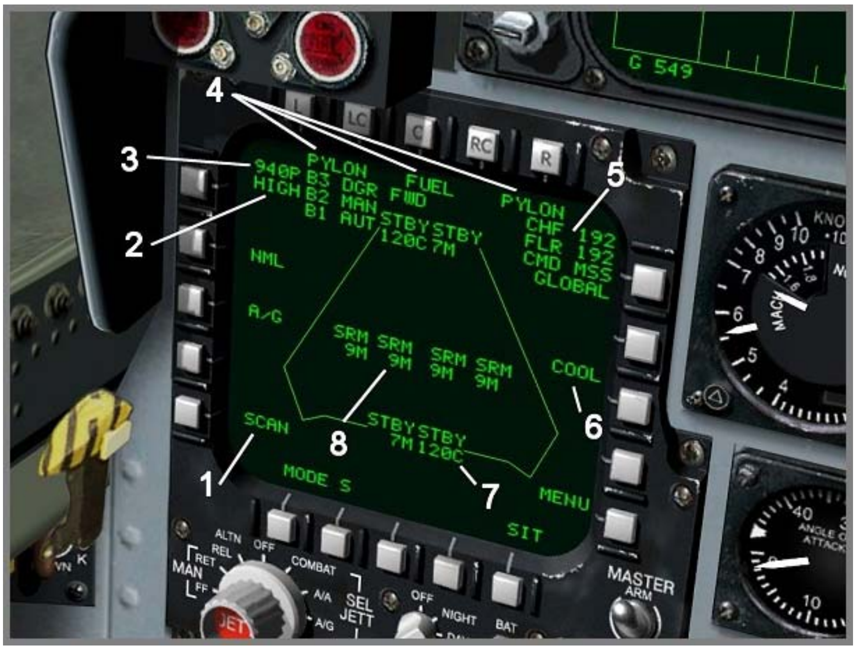
Learning to fly a stabilized ILS is imperative to be able to bring your jet back home safely. There might be occasions where, due to battle damage or failures, you will have to rely on the instrument panel only so it is a good idea to practice heads down ILS approaches without looking at the HUD until short final.

Bringing the jet home in very poor weather after a difficult combat mission is very rewarding!

# F-15C Programmable Armament Control Set (PACS) Training

Welcome to Programmable Armament Control Set(PACS) training for the F-15C. In this tutorial you will learn about the PACS and the information it provides to keep you informed of the status of the stores on your aircraft.

The PACS is a Multi Purpose Color Display(MPCD) that displays the location and status of the external stores and expendable countermeasures loaded on the jet. It also provides information on the firing rate and rounds remaining for the Vulcan cannon..




1. AIM-9 SCAN mode indicator.
2. Vulcan cannon firing rate.
3. Vulcan cannon rounds remaining.
4. External fuel tank status.
5. Chaff and Flare status.
6. Infrared seeker cooling status.
7. Air to air missile in Standby.
8. AIM-9 Short Range Missile.

- When an air to air missile is armed, it will be enclosed by a box with the ‘RDY’ symbol.
- When an external tank station is empty it will be replaced with the ‘PYLON’ symbol.
- When the master arm is selected ‘On’, the ‘COOL’ symbol will be boxed.

# F-15C Tactical Electronic Warfare System(TEWS) Training

Welcome to Tactical Electronic Warfare System(TEWS) training for the F-15C. In this tutorial you will learn about the TEWS and the information it provides to help keep you aware of the threats facing you from the air, land, and sea. The TEWS receives, interprets, warns, and displays radar emitting threats to your aircraft using visual and aural warnings.

The TEWS system includes the Loral AN/ALR-56 Radar Warning Receiver(RWR) which provides electronic detection and identification of both surface and airborne threats. In addition, the TEWS allows for activation of appropriate countermeasures including electronic jamming and dispensing of expendables such as chaff and flares.

The TEWS display will tell you the following information:

1. The radar emitter mode, search, lock, or launch.
2. The bearing of the emitter in relation to your jet.
3. The general type of the emitter such as airborne, naval, or ground based.
4. The specific type of emitter such as a particular SAM or aircraft.

**TEWS Scope**

Information from the AN/ALR-56 RWR is displayed on a monochromatic CRT display located on the top right of the instrument panel.


- The center cross is your aircraft from a top down perspective.
- The inner/lock zone ring will display emitters that have locked onto your jet.
- The outer most ring is the search zone where the emitters that have detected your jet but have not locked on are placed and around the search zone of the display are bearing dots. The bearing dots are always on the display and always remain static.

The TEWS has three declutter filters, which display only specific emitter information. They are as follows.

1. **Show all:** will display all emitters illuminating your jet.
2. **Show only lock:** will display only the emitters that have locked onto your jet.
3. **Show only launch:** will display only the emitters that have launched a missile at your jet.

You can cycle the TEWS filters by pressing the **‘SHIFT-R’** keys.

## TEWS Threat Symbols

There are several types of emitter symbols as detailed below.

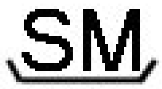
The different radar will be divided into five general categories.  These categories are similar to the manner in which emitters are categorized in Flanker 2.0.  These general categories are:

- Early Warning Radar (EWR).
    - All early warning radar will be included in this category and all we be represented as an "EW" icon on the RWR scope.


- Aircraft radar.
    - All aircraft with an air-to-air radar will be included in this category.  Emitters in this category will have a " ^ " above their icon.


- Ground-based radar.
    - All surface-to-air missile and radar directed anti-aircraft artillery are included in this category.  Emitters in this category will have a box around their icon.


- Naval-based radar.
    - All naval engagement radar will be represented in this category.  Emitters in this category will be an upward facing bracket below their icon.




- Active missile.
    - Terminal Active Radar Homing (TARH) missiles like the R-77, AIM-120, and AIM-54 are included here.  Emitters in this category will have a diamond around their icon.


All specific emitter ID's are found in the Lock On manual on page 77.

## TEWS Warning Indications

The TEWS will display warnings to you via visual symbols and aural tones.

- The warning for a search spike is a single tone and a specific emitter symbol appearing on the outer ring.
- The warning for a radar lock on is a constant tone and an accompanying emitter symbol in the inner ring.
- The warning for a missile launch is a repetitive tone and a flashing emitter symbol in the inner ring.

The A-10A Radar Warning Receiver will also display the above emitter symbols and warnings.

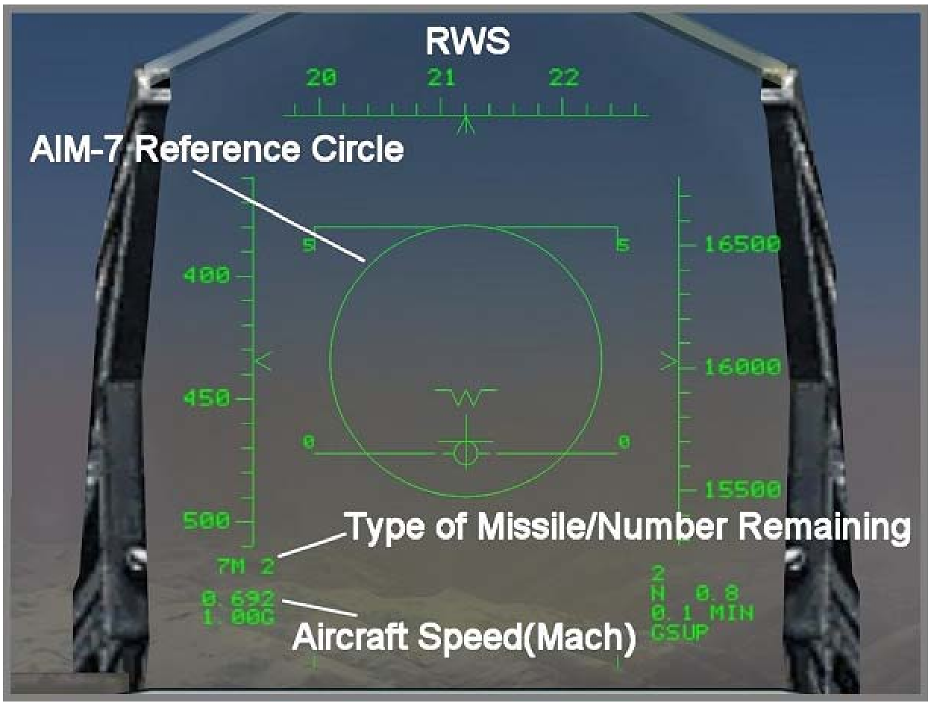
# F-15C AN/APG-63 Radar Training

Welcome to Beyond Visual Range(BVR) radar training for the F-15C Eagle. In this tutorial you will learn how to use the powerful Hughes AN/APG-63 pulse Doppler fire control radar to acquire and engage airborne targets. You will learn how to use the Range While Search(RWS), Track While Scan(TWS), and Single Target Track(STT) radar modes and interpret the data on the HUD and Vertical Situation Display(VSD). Using this information you will learn how to engage airborne targets with The AIM-7M Sparrow medium range semi-active guided and the AIM-120C AMRAAM advanced medium range active radar guided missiles.

Located in the nose, the APG-63 radar is a highly effective, all-weather multi-mode radar. The APG-63 combine's long-range acquisition and attack capabilities with automatic features to provide the instant information and computations needed during air-to-air combat operations.

The following sections will detail the HUD and Vertical Situation Display(VSD) for the radar modes of the APG-63.

The diagram below shows the Range While Search(RWS) HUD with the AIM-7M Sparrow active.

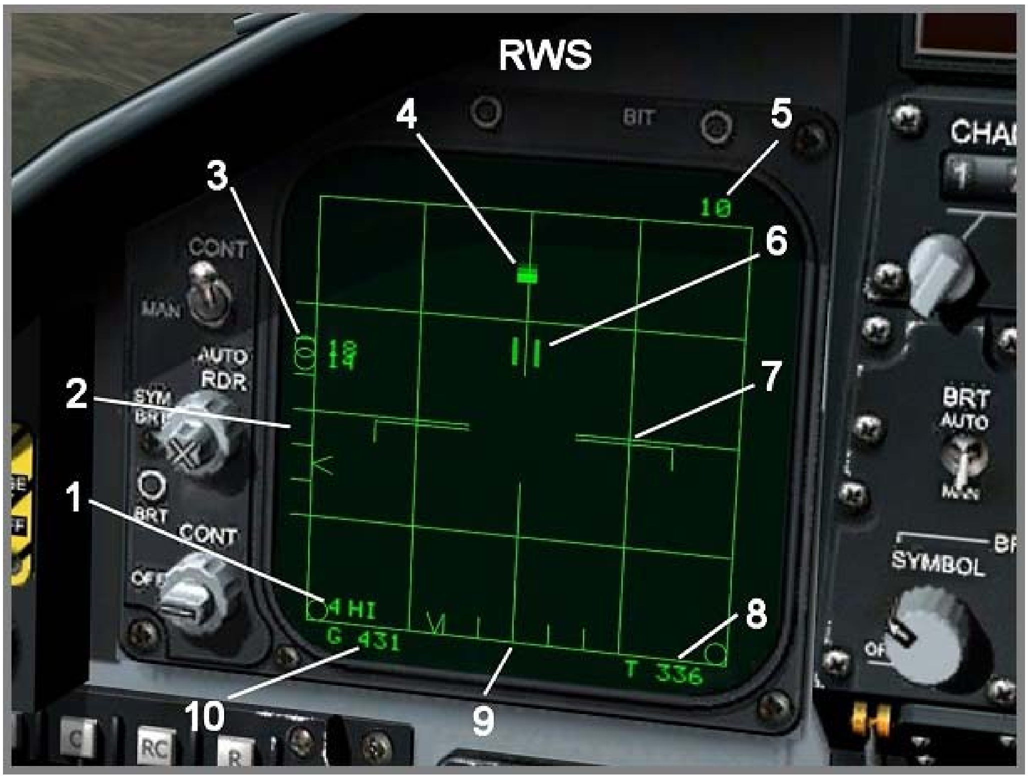



Range While Search(RWS)

Range While Search is the primary mode used for locating airborne targets and provides range and azimuth information on the VSD. This mode will continually illuminate all contacts within the antenna beam scan volume. In RWS mode, illuminated targets will appear as solid 'tracks' on the VSD. RWS mode will display up to 16 targets simultaneously on the VSD.

In RWS radar mode, the antenna elevation can by moved up and down and the azimuth can be set to scan either 30 degrees or 60 degrees each side of center for a total azimuth scan of 60 degrees and 120 degrees.

The diagram below shows the VSD in search mode.

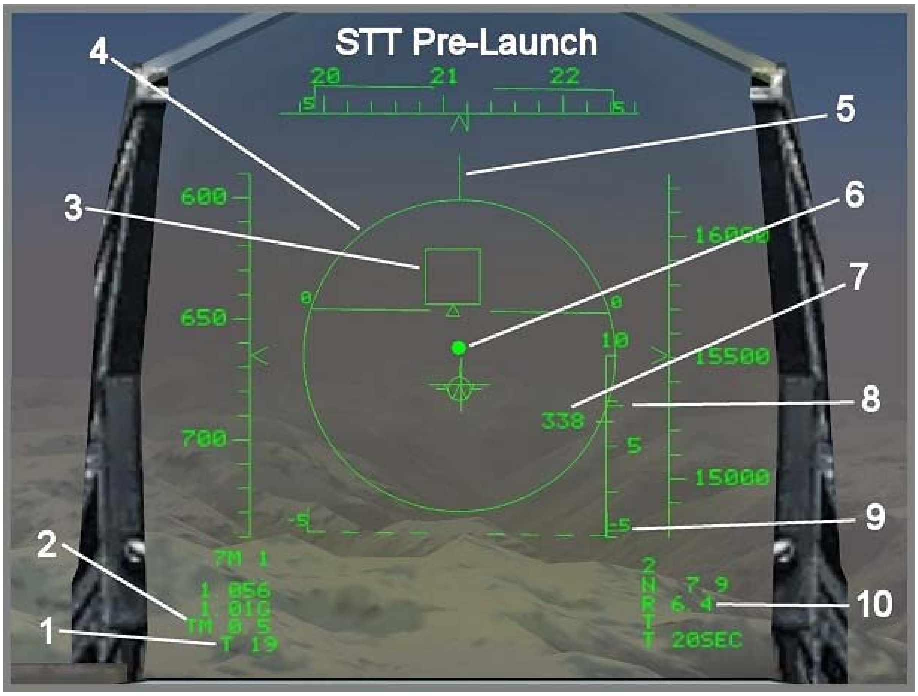



1. BAR and PRF indicator.
2. Antenna elevation scale.
3. Antenna elevation coverage.
4. Hostile Track.
5. Range scale.
6. Target Designation Cursor(TDC).
7. Horizon bar.
8. Aircraft true airspeed.
9. Antenna azimuth scale.
10. Aircraft groundspeed.

**To use RWS in Search mode:**

1. Press the **'2'** key to activate the Air to Air master mode and enter RWS mode.
2. Press the **' i '** key to activate the APG-63 radar.
3. Press the **'D'** key to cycle the missiles.
4. Adjust range with the **'='** and **'-'** keys.
5. Adjust the antenna elevation up and down with the '**SHIFT-SEMI-COLON(;)**' and '**SHIFT-PERIOD(.)**' keys.
6. Adjust the antenna azimuth to 60 degrees or 120 degrees with the '**CTRL+**' and '**CTL-**' keys.
7. Slew the TDC by pressing the '**PERIOD(.)**', **SEMI-COLON(;)**', '**COMMA(,)**', and '**FORWARD SLASH(/)**' keys.

Once a target is locked in RWS mode, the APG-63 will enter Single Target Track(STT) mode. In this mode, all of the radar's energy is being directed at the Primary Designated Target(PDT) so no other targets will appear on the VSD.




1. Time To Impact(TTI) timer.
2. Target Mach.
3. Target Designation box(TD box).
4. ASE circle with aspect angle line.
5. Aspect angle line.
6. Dynamic Launch Zone (DLZ).
6. Steering Dot.
7. Target closure speed.
8. RTR cue.
9. RMIN cue.
10. Target range.
12. Target aspect angle.


1. STT indicator.
2. Target altitude.
3. Target airspeed.
4. Target aspect angle.
5. Target heading.
6. Primary Designated Target(PDT).
7. Allowable Steering Error circle(ASE).
8. Steering Dot.
9. Target closure speed.
10. Dynamic Launch Zone(DLZ).
11. Target range.
12. Target bearing.
13. Pre-launch Time To Impact(TTI) timer.
14. NCTR indicator.

**To Lock a and Fire on a Target with a AIM-7M:**

1. Lock on and enter STT mode by pressing the **'TAB'** key as indicated by a PDT and 'STT' on the VSD.
2. Once in range as indicated by the shoot cue and the full sized ASE circle, press the **'SPACEBAR'** key.
3. Watch the TTI timer on the bottom left of the HUD for the count to reach zero before breaking the lock.
4. Break the lock on the PDT by pressing the **'CTRL-TAB'** keys.

When a missile is launched in STT mode, the HUD and VSD will switch to the 'post-launch' mode. The post launch mode is identical to the pre-launch mode with the exception of the Time To Impact(TTI) timer on the HUD and VSD as seen in the diagrams below.


<STT Post-Launch HUD>

The procedure when using an AIM-9 in RWS is identical to the AIM-7 with the exception of the AIM-9 growl and lock tones and the fact it is a fire and forget missile so maintaining radar lock in not required.

The procedure when using an AIM-120 in RWS mode is identical to the AIM-7 with the exception that the AIM-120 will display a post launch Time To Active(TTA) timer and when the TTA reaches zero you can break the radar lock.

**Track While Scan(TWS) Mode**

Track While Scan is the primary mode used when engaging multiple targets. TWS mode will provide range, azimuth, aspect, and altitude information on the VSD. TWS will not provide continuous updates and will only display a track after each 3 bar scan. This mode will continually track all contacts within the antenna beam scan volume. In TWS mode, illuminated targets will appear as hollow tracks with an attached angle off target line and with their altitude displayed above the track on the VSD.

In TWS mode the TDC will also adjust the antenna elevation up and down as indicated on the elevation scale..

When using the AIM-120 AMRAAM while in TWS mode, the AGP-63 will allow simultaneous engagement of up to 8 targets. This means you will be able to launch up to 8 AIM-120s at 8 separate targets at the same time.

The diagram below shows the VSD in pre-launch mode.


<TWS Search VSD>

1. TWS indicator.
2. Hostile track.
3. Friendly track.
4. Target angle off line.
5. Target altitude.

In TWS mode you can both designate or 'bug' a track and lock onto a track in STT mode. The first track you bug becomes the PDT, the second one becomes a SDT as indicated by a '1' to the right side of it, and each subsequent track bugged will have an ascending number beside it starting with '2'. The ASE circle, steering dot, and all target information will be for the PDT only.

To place a PDT into STT mode while in TWS, bug the PDT a second time. Entering STT mode from TWS mode will remove all other tracks and will only display the PDT on the VSD.

**To use TWS in Search mode:**

1. While in RWS mode, press the **'ALT-i '** keys to enter TWS mode.
2. Adjust range with the **'='** and **'-'** keys.
3. Adjust the antenna elevation up and down with the TDC or the '**SHIFT-SEMI-COLON(;)**' and '**SHIFT-PERIOD(.)**' keys.
4. Adjust the antenna azimuth to 60 degrees or 120 degrees with the '**CTRL+**' and '**CTL-**' keys.
5. Slew the TDC by pressing the '**PERIOD(.)**', **SEMI-COLON(;)**', '**COMMA(,)**', and '**FORWARD SLASH(/)**' keys.
6. 'Bug' a track by pressing the **'TAB'** key and it will become the PDT.
7. Place the PDT into STT by slewing the TDC over the PDT and pressing the **'TAB'** key again.

When using TWS mode you can both designate or 'bug' a track and lock onto a track in STT mode. The first track you bug becomes the PDT, the second one becomes a SDT as indicated by a '1' to the right side of it, and each subsequent track bugged will have an ascending number beside it starting with '2'. The ASE circle, steering dot, and all target information will be for the PDT only.

To place a PDT into STT mode while in TWS, bug the track a second time. Entering STT mode from TWS mode will remove all other tracks and will only display the PDT on the VSD.


The only difference between TWS post-launch and STT post-launch is that all the tracks will remain displayed on the VSD.

**To Launch at a Single Target or on Multiple Targets(AIM-120 only) in TWS mode:**

1. 'Bug' a track by slewing the TDC over the track and pressing the **'TAB'** key.
2. 'Bug' additional tracks by slewing the TDC over each track and pressing the **'TAB'** key.
3. Once in range press the **'SPACEBAR'** to fire a missile at the PDT.
4. Once the missile is away the SDT will become the new PDT, press **'TAB'** to fire.
5. Continue rippling AIM-120s at all the bugged tracks.

# F-15C Gun and AIM-9 Training

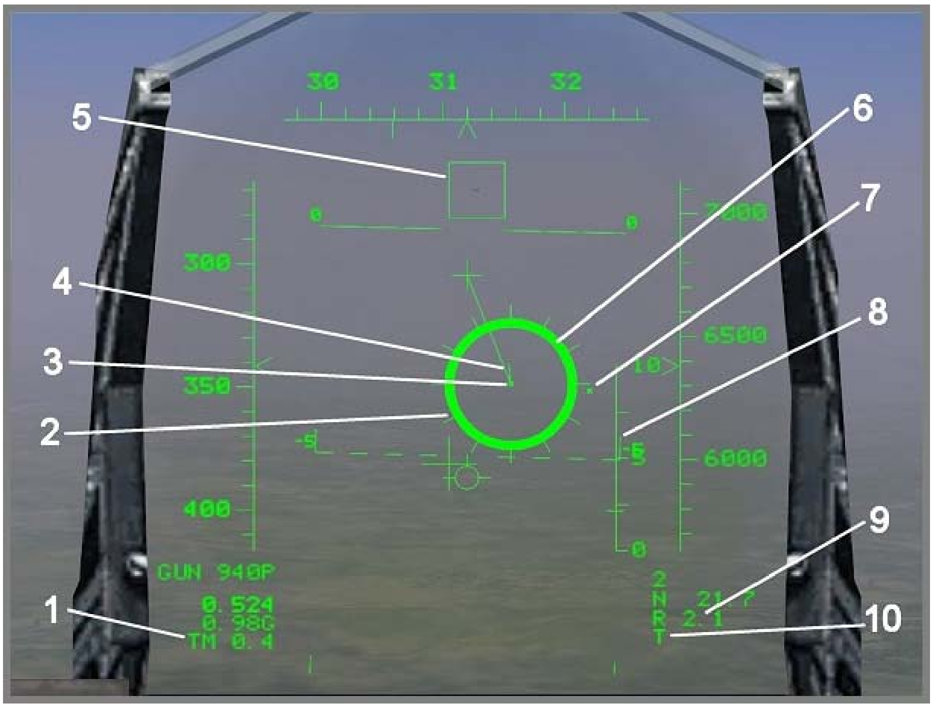
Welcome to Gun and AIM-9 training for the F-15C. In this tutorial you will learn how to use the General Electric M61A1 Vulcan rotary cannon and the AIM-9M Sidewinder heat seeking short-range dogfight missile with and without the APG-63 radar.

Located in the right wing root, the M61A1 is a six barreled 20mm rotary cannon capable of firing 6000 rounds per minute in the 'HIGH RATE' and 4000 rounds per minute in the 'LOW RATE'. The ammunition drum will hold 940 rounds of PGU-38 shells. We can change the firing rate by pressing the '**SHIFT-C**' keys and note the change on the upper left of the PACS.

### Auto Acquisition Guns(AACQ) Steering Mode

When the gun is selected the APG-63 radar is automatically activated in a 60 degree azimuth and 20 degree elevation scan pattern as noted on the VSD. On the HUD, a fixed Lead Computing Optical Sight(LCOS) reticule is displayed approximately one degree below the gun cross and rounds remaining are shown below the speed tape. At the center of the reticule is a piper and in this mode, the radar provides a scan pattern with an auto acquisition capability that ranges from 500 feet to 10 miles in range.

Once the radar locks onto a target, a TD box will appear around the target and a dynamic LCOS pipper will replace the fixed LCOS reticule.




1. Target mach.
2. LCOS dynamic pipper.
3. Death dot.
4. Lag line.
5. TD box.
6. Range clock.
7. Bullet maximum range cue.
8. Range scale and target closure speed.
9. Target range.
10. Target aspect angle.

**To use the Guns Steering Auto Acquisition Mode:**

1. Press the **'C'** key to enter guns steering mode.
2. Maneuver the jet to place the bandit within the HUD field of view.
3. Once the radar has automatically locked onto the target the dynamic LCOS pipper will be displayed.
4. Continue maneuvering to place the death dot of the LCOS pipper over the bandit.
5. When in range as indicated by the LCOS range clock, hold the **'SPACEBAR'** key to fire the gun.

**AIM-9 Missile Modes**

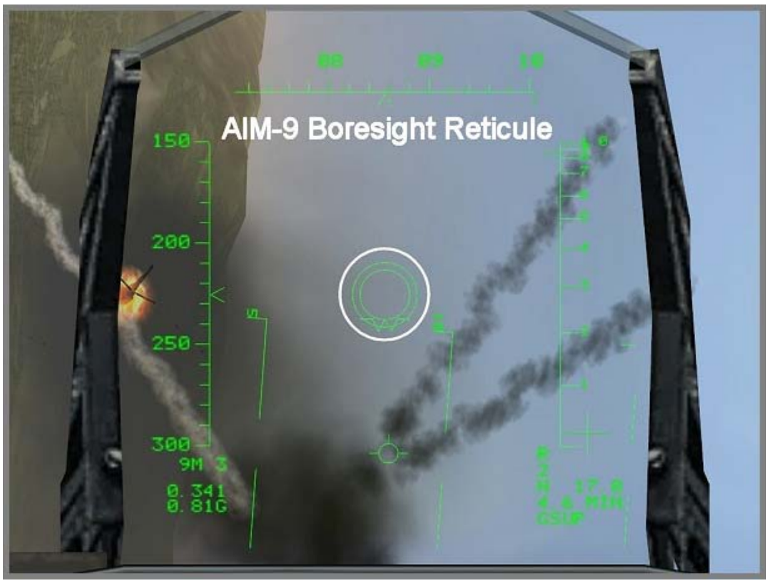
The AIM-9M Sidewinder is a supersonic all aspect infrared guided heat seeking short range missile and will be your primary weapon in dogfight situations.

The AIM-9M has 3 different modes including radar assisted and non-radar modes:

1. AIM-9 Boresight
2. AIM-9 SCAN
3. AIM-9 Radar line of sight slave.

AIM-9 Boresight Mode

The AIM-9  Boresight mode uses the missiles own seeker aimed straight out along it's longitudinal axis to self search and lock onto a target.  This mode requires no radar sensor input.




To use the AIM-9 Boresight Mode:

1. Press the **'2'** key to enter the Air to Air master mode.
2. Press the **'D'** key to cycle missile stations to the AIM-9M.
3. Press the **'6'** key to activate the AIM-9 Boresight mode.
4. Maneuver the jet to place the bandit within the boresight reticule.
5. When a high pitch lock on tone is heard press the **'SPACEBAR'** to fire.
6. Keep the bandit within the boresight reticule until the missile has either hit or missed.

AIM-9 SCAN Mode

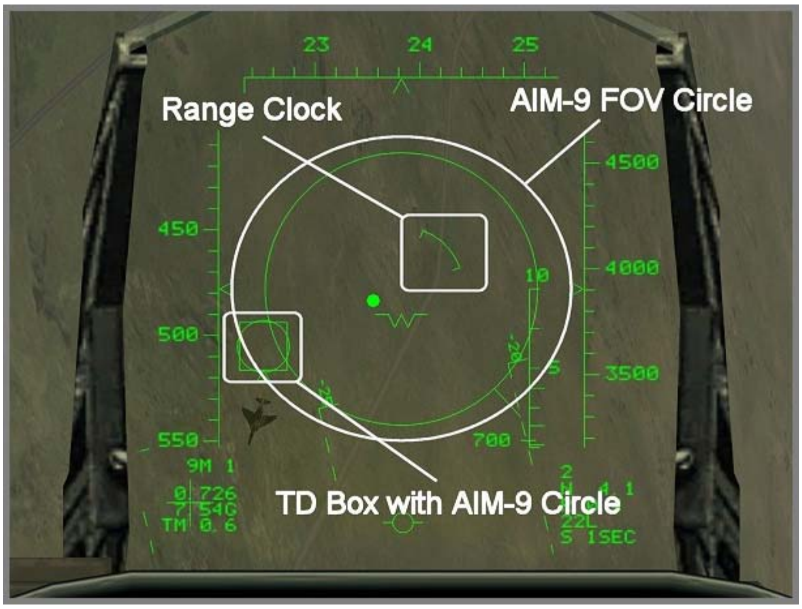
In this mode the seeker is searching the area within its gimbal limits so acquiring and maintaining a lock is much easier for the seeker. The HUD displays a field of view for the uncaged seeker.   When in the AIM-9 SCAN mode the word 'SCAN' on the PACS will be enclosed in a box.

**To use the AIM-9 SCAN mode:**

1. Press the **'2'** key to enter the Air to Air master mode.
2. Press the **'D'** key to cycle missile stations to the AIM-9.
3. Press the **'4'** key to activate the AIM-9 SCAN mode.
4. Maneuver the jet to place the bandit within the scanning field of view circle.
5. When a high pitch lock on tone is heard press the **'SPACEBAR'** to fire.

**AIM-9 Radar Line of Sight Slave mode**

In this mode the selected AIM-9 has its seeker head position circle automatically slaved to the radar antenna's line of sight target. The HUD displays an SRM Field Of View (FOV) circle and when the target is locked it will have an internal range clock and the TD box will have a circle inside it.




**To use the AIM-9 Radar Line of Sight Slave mode:**

1. Press the **'2'** key to enter the Air to Air master mode.
2. Press the **' i '** key to activate the radar.
3. Press the **'D'** key to cycle missile stations to the AIM-9.
4. Lock a target by slewing the TDC and pressing the **'TAB'** key.
5. When in range clock indicates you are in range and a high pitch lock on tone is heard press the **'SPACEBAR'** key to fire

# F-15C Within Visual Range Training

Welcome to Within Visual Range(WVR) training for the F-15C Eagle. In this tutorial you will learn how to use the AN/APG-63's Auto Acquisition modes with the AIM-120 AMRAAM and the AIM-9 Sidewinder. You will also learn how to use the AIM-120 Visual and the AIM-7 FLOOD modes.

## Auto Acquisition(AACQ) Modes

Auto Acquisition(AACQ) modes use preset radar antenna scan volumes for short range intercepts within visual range. The radar will automatically lock onto a target that is inside the scan zone within 10 nautical miles. The radar will then place the target into STT mode and the normal radar lock pre and post-launch HUD symbology will be present. When the target flies outside the scan volume, the STT lock will be broken and the radar will revert back to the preset AACQ scan volume.

The APG-63 has the following 3 Auto Acquisition modes:

1. Guns Steering mode, which is detailed in the Gun and AIM-9 tutorial.
2. Radar Boresight mode
3. Vertical Scan mode

### Radar Boresight AACQ Mode

The Boresight mode is useful for quickly engaging targets in the front quarter. The radar antenna slaves to the boresight position of the radar and continually searches in range from 500 feet to 10 nautical miles along the antenna line of sight.

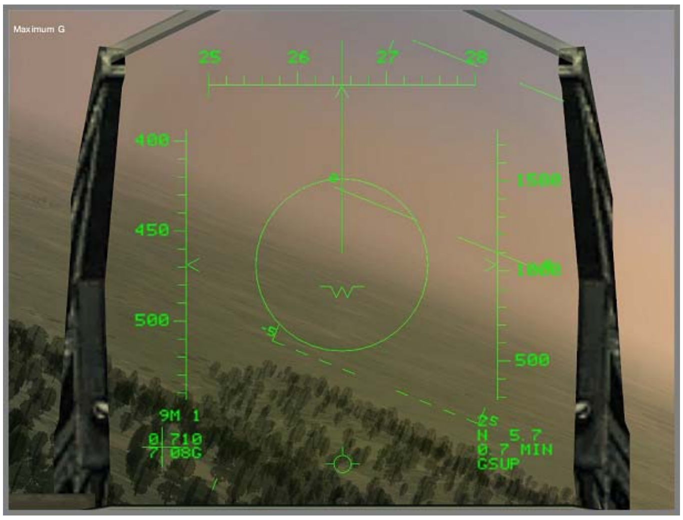

<Radar Boresight AACQ HUD>

**To use the Radar Boresight Auto Acquisition Mode:**

1. Press the **'4'** key to activate the Boresight AACQ mode.
2. Press the **'D'** key to cycle missile stations to the missile you want to fire.
3. Maneuver the jet to place the bandit within the boresight reference circle.
4. Once the radar has automatically locked onto the target the STT radar lock symbology will be displayed.
5. Press the **'SPACEBAR'** key to fire.

### Vertical Scan AACQ Mode

The Vertical Scan AACQ mode is used primarily when you are in a situations where you are performing hard turning maneuvers, or in a dogfight. In this mode the radar antenna is preset to scan vertically, from +5 degrees to +55 degrees and 7.5 degrees in azimuth using a 2 bar scan pattern. The radar has a lock on capability from 500 feet to 10 nautical miles.

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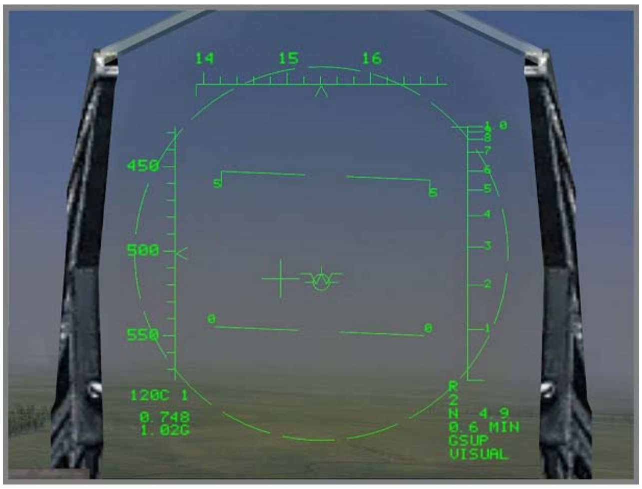
### To use the Vertical Scan AACQ Mode:

1. Press the **'3'** key to activate the Boresight AACQ mode.
2. Press the **'D'** key to cycle missile stations to the missile you want to fire.
3. Maneuver the jet to place the bandit within the vertical scan volume.
4. Once the radar has automatically locked onto the target the STT radar lock symbology will be displayed.
5. Press the **'SPACEBAR'** key to fire.

It is important to remember that when using the AACQ modes with the AIM-7M, the radar lock must be maintained the entire time of flight to impact. With the AIM-120 and AIM-9, the missile can be fired with no further radar support.

### AIM-120 Visual Mode

In this mode the AIM-120 will use it's on board radar to lock any target within 15 miles. The AIM-120's onboard radar will scan 15 nautical miles ahead of the jet and display a 12 degree dashed reference circle on the HUD. In the AIM-120 Visual mode, a radar lock on is not required.




**To use AIM-120 Visual mode:**

1. Press the **'2'** key to enter the Air to Air master mode.
2. Press the **'D'** key to cycle missile stations to the AIM-120.
3. Press the **'6'** key to activate the AIM-120 Visual mode.
4. Maneuver the jet to place the bandit within the AIM-120 reference circle.
5. Press the **'SPACEBAR'** to fire.

**AIM-7 Flood mode**

In this mode the radar provides illumination ahead of the jet out to 10 nautical miles. A solid 12 degree reference circle and the word 'FLOOD' is displayed on the VSD.


**To use AIM-7 Flood mode:**

1. Press the **'2'** key to enter the Air to Air master mode.
2. Press the **' i '** key to activate the radar.
3. Press the **'D'** key to cycle missile stations to the AIM-7.
4. Maneuver the jet to place the bandit within the AIM-7 reference circle within 10 nautical miles.
5. Press the **'SPACEBAR'** to fire.
6. Continue to maneuver the jet to keep the target within the AIM-7 reference circle for the entire time of flight to impact.

# F-15C Home On Jam Training

Welcome to Home on Jam(HOJ) training for the F-15C Eagle.  In this tutorial you will learn how to use the passive capability of the AIM-120 AMRAAM and the AIM-7 Sparrow to engage aircraft that are using electronic jamming equipment to reduce the effectiveness of the APG-63 radar.

If a hostile aircraft is jamming your aircraft to the extent that your radar cannot detect it or acquire a lock, a vertical strobe will appear on the VSD giving the bearing of the jamming aircraft only.  This strobe does not provide altitude or range information.  Once you are inside the jamming range of the hostile aircraft, the strobe will be replaced by the normal RWS or TWS symbology.



**To use the Home on Jam capability of the AIM-120 and AIM-7:**

1. Press the **'2'** key to enter the Air to Air master mode.
2. Activate the radar by pressing the **'i '** key.
3. Press the **'D'** key to cycle missile stations to either the AIM-120 or AIM-7.
4. Wait until jamming strobes appear on the VSD.
5. Slew the TDC over the strobes.
6. Press the **'TAB'** key lock the passive seeker onto the jamming aircraft.
7. Press the **'SPACEBAR'** to fire.

It is important to remember that the HOJ strobes will not provide range, altitude, or aspect information.

# Su-27 Introduction and Instrument Approach Training

Welcome to Instrument Approach training for the Su-27. In this tutorial you will learn, in detail, about the information displayed on the HUD to conduct an instrument approach to landing which is required when the weather is poor or the cloud bases are low. Instrument flying is another skill that must be mastered in order to bring your jet back to the earth safely in all conditions.

The Flanker is an all weather day/night air superiority fighter aircraft powered by two powerful Lyulka Saturn AL-31F afterburning turbofan engines each rated at 12,500 KG static thrust and is capable of reaching 2500 km/h or Mach 2.35 with a service ceiling of 18,500 meters.

The Su-27 uses conventional instruments for flight, navigation, and standard aircraft systems. Combat sensors and weapons management are displayed on 2 displays consisting of a Multi Function Display(MFD) CRT and a Radar Warning Receiver(RWR) display.

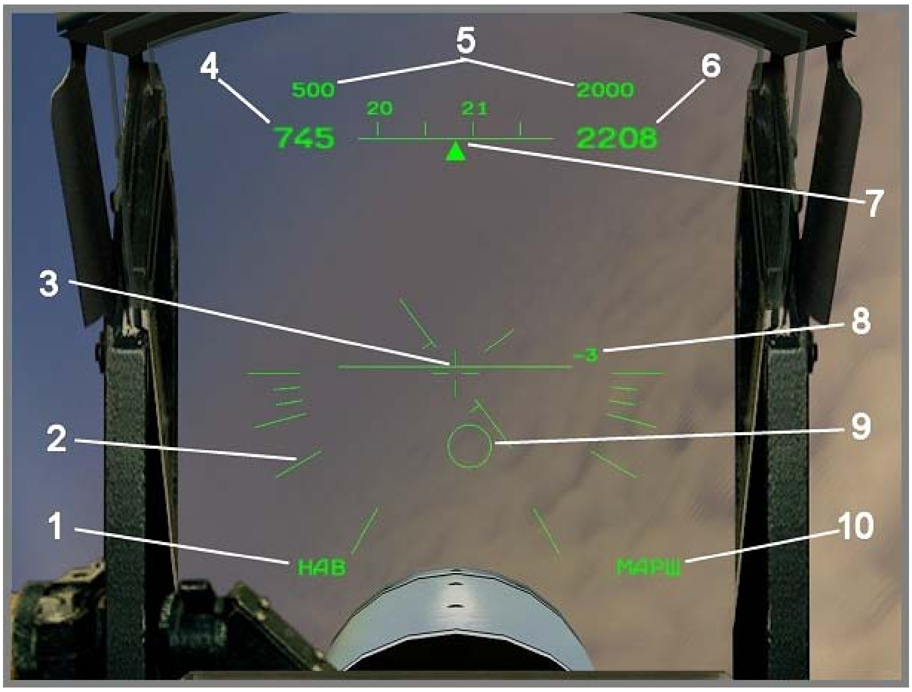
This tutorial also applies to the Su-33 Naval Flanker and the Mig-29 Fulcrum. The Su-25 uses the ADI, HSI, and distance gauge for instrument and ILS approaches.

It is a good idea to go over the flightplan of your mission before starting and write down the required course, altitude, and speed for each waypoint and the airport. You can enter this information on the flightplan document included at the end of this manual in the 'Pilot Reference' section.

When you start a flight and enter the cockpit you will automatically be in the enroute navigation mode.

**Russian HUD Symbology**

The Russian HUD is very different from it's western counterpart with the main differences being the absence of a pitch ladder, which is replaced by an aircraft datum symbol and horizon line, and a velocity vector indicator. Additionally, all information is displayed in metric; kilometers per hour, meters, and kilometers.

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1. HUD master mode.
2. Bank angle indication lines.
3. Aircraft datum and the horizon reference line.
4. Digital airspeed indicator.
5. Required airspeed and altitude.
6. Digital Barometric altimeter indicator.
7. Heading tape and caret.
8. Numerical pitch indicator.
9. HUD steering circle.
10. HUD sub-mode.

- **Aircraft datum and the horizon reference line:** Displays the attitude of the jet from a tail on viewpoint.
- **Numerical pitch indicator:** Displays the pitch of the jet in reference to the horizon.
- **Bank angle indication lines:** Displays 10, 20, 30, and 60 degrees of bank.
- **Digital Airspeed Indicator(ASI):** Displays the aircraft's airspeed.
- **Heading Tape and caret:** Displays the aircraft's magnetic heading as a scrolling tape and at the bottom center of the tape is a caret that marks the aircraft's current heading.
- **Digital Barometric Altimeter:** Displays the aircraft's altitude above mean sea level at all times.
- **HUD master mode:** Displays the navigation or combat master mode.
- **HUD sub-mode:** Displays the navigation or combat sub-mode.
- **HUD steering circle:** Provides vertical and lateral guidance to a waypoint, IAF, or FAF.
- **Required speed and altitude:** Displays the speed and altitude for the flightplanned waypoints.

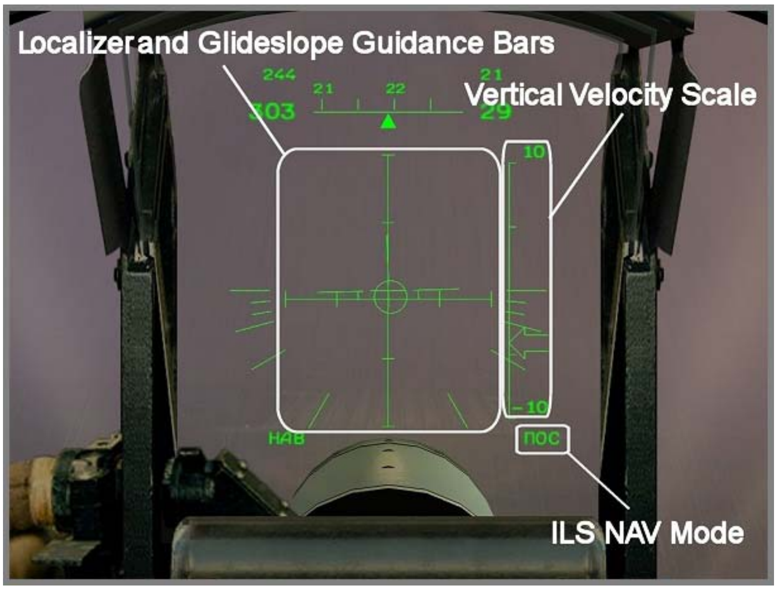
The navigation instruments on the panel are identical to the Su-25 with the exception of a Mach scale on the airspeed indicator, the absence of a waypoint distance gauge, and the addition of digital waypoint distance and course indications on the HSI.

The aircraft in Lock On have 4 different navigation modes as detailed below. The navigation modes can be cycled with the **'1'** key.

1. **Basic free flight mode(HAB):** Displays no navigation information and is used for free flight and practicing flight maneuvers.
2. **Enroute navigation mode(MAPW):** Displays waypoint navigation information on the HUD, ADI, and HSI.
3. **Return navigation mode(B03P):** Displays navigation information to the Initial Approach Fix(IAF), which will set you up for an approach and landing at an airport.
4. **ILS navigation mode(NOC):** Displays navigation information to the Final Approach Fix(FAF) followed by the Instrument Landing System(ILS) information to an airport.

You can cycle the waypoints and airport IAFs and FAFs by pressing the **'TILDE~'** key.

Su-27 ILS HUD Symbology




1. **Localizer and glideslope guidance bars:** Displays the position of the landing gear, flaps, and speed brakes.

2. **Vertical descent scale:** Displays climb and descent rates.

3. **ILS NAV mode indication:** 'NOC' ILS sub-mode indication.

Instrument Flight Navigation to the IAF

1. Press the **'1'** key to cycle navigation modes until **'B03P'** appears as the sub-mode on the HUD.
2. Turn the jet so the HUD steering circle is centered over the aircraft datum and the waypoint bearing needle is pointing up. This will give you a direct route to the IAF.
3. Climb or descend as required by the waypoint altitude information on the top right of the HUD.
4. 5 km from the IAF you should have slowed to about **400 km/h**. Extend the flaps by pressing the **'F'** key.
5. Continue to the IAF and the NAV computer will automatically select the ILS mode when you are within range.

Instrument Flight Navigation to the FAF

1. Press the **'1'** key to cycle navigation modes until **'NOC'** appears as the sub-mode on the HUD.
2. Turn the jet so the HUD steering circle is centered over the aircraft datum and the waypoint bearing needle is pointing up. This will give you a direct route to the FAF.
3. Climb or descend as required by the waypoint altitude information on the top right of the HUD.
4. 5 km from the FAF you should have slowed to about **350 km/h** with the flaps extended.

Instrument Landing System(ILS) Approach and Landing

5. At this point in the approach you will be in the ILS mode as indicated by the **'NOC'** sub-mode on the HUD.
6. At glideslope intercept extend the landing gear by pressing the **'G'** key and turn on the landing lights with 2 presses of the '**ALT-L**' keys.
7. Increase thrust to about 80% N1 to maintain **330-350 km/h**. Confirm 3 Green and flaps set.
8. Keep the ILS localizer and glideslope bars crossed in the center of the HUD by maneuvering to keep the steering circle centered over the aircraft datum. Confirm with the ADI flight director and the HSI ILS guidance bars.
9. Maintain a **5 meter/second** descent rate and **330-350 km/h** down the glideslope.
10. Once visual and on short final, slowly reduce speed to cross the threshold at **300 km/h** and flare to the landing.

While on an ILS it is imperative to make very small corrections and thrust changes to maintain a stabilized approach.

### Missed Approach

In the event you do not see the runway you must execute a missed approach.

- Pitch nose up to 10 degrees.
- Set maximum thrust with afterburner.
- At positive rate on the variometer, raise the landing gear.
- Once the gear is up, raise the flaps.
- Continue climb to at least 1000 meters above ground and then turn on course to your alternate airport.

Learning to fly a stabilized ILS is vital if you wish to bring your jet back home safely. There might be occasions where, due to battle damage or failures, you will have to rely on the instrument panel only so it is a good idea to practice heads down ILS approaches without looking at the HUD until short final.

Bringing the jet home in very poor weather after a difficult combat mission is very rewarding!

# Su-27 N001 Zhuk Radar Training

Welcome to Beyond Visual Range(BVR) radar training for the Su-27. In this tutorial you will learn how to use the Phazotron N001 Zhuk coherent pulse Doppler fire control radar. You will learn how to access and manipulate the Search mode and interpret the data on the HUD and Multi Function Display in order to engage airborne targets with the Vympel R-27 Alamo family of air to air medium and long range semi-active and terminal active radar guided missiles.

In Russian aircraft, the HUD is the location where all target information is displayed and where you slew the Target Designation(TD) Box over the tracks to lock the radar onto the targets. The MFD displays radar elevation and azimuth settings, locked targets, and AWACS datalink information only.

This tutorial also applies to the Su-33 Naval Flanker and the Mig-29 Fulcrum.

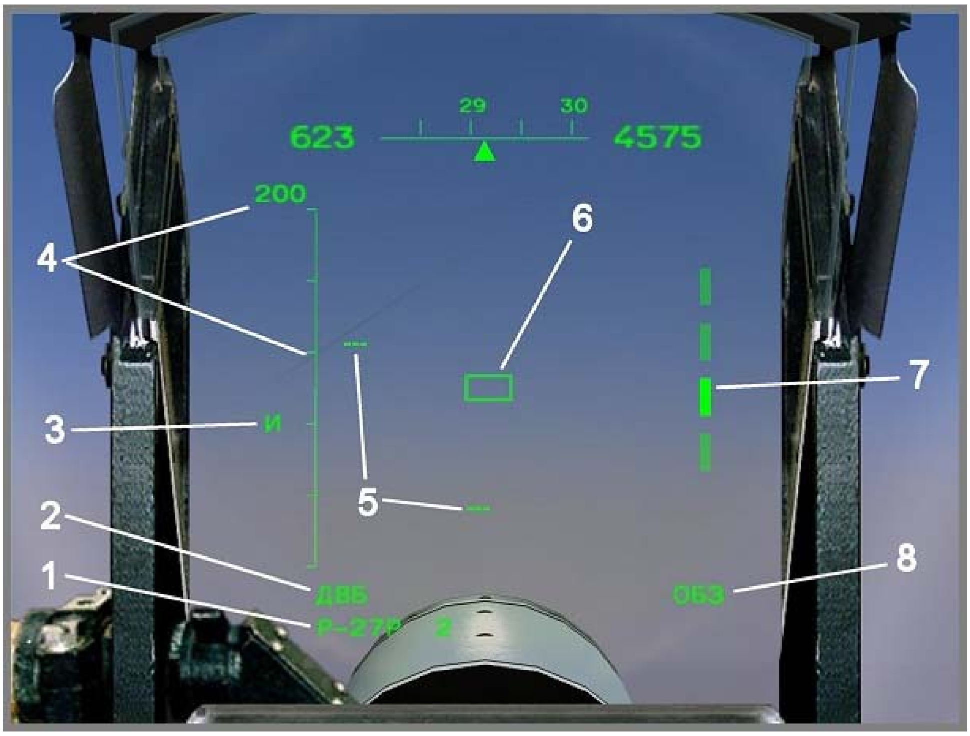
The following sections will detail the HUD and Multi Function Display(MFD) for the radar modes of the N001 Zhuk radar. The diagram below shows the search HUD with the R-27RE active.

Please refer to the N001 Zhuk section in the manual for detailed descriptions of the elements of the HUD and MFD.

### Radar Search Mode

Search is the primary mode used for locating airborne targets but will only provide range and azimuth information on the HUD. This mode will continually illuminate all contacts within the antenna beam scan volume. In Search mode, illuminated targets will appear as 3-dot horizontal ‘tracks’ on the HUD. Search mode will display up to 10 targets simultaneously on the HUD. The diagram below shows the HUD in search mode.

In Search radar mode, the radar antenna elevation can by moved up and down and the azimuth can be moved left and right.

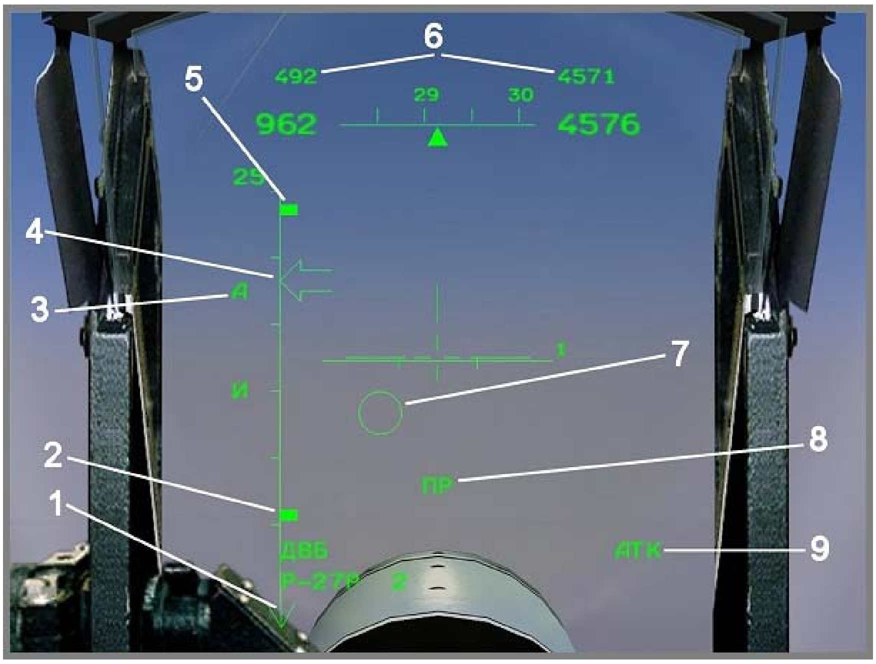



1. Missile type and number.
2. BVR mode symbol.
3. Active radar symbol.
4. Range scale.
5. Hostile Track.
6. Target Designation(TD) Box.
7. Antenna elevation indicators.
8. Search mode indicator.

To use Search mode:

1. Press the **'2'** key to activate the Air to Air master mode and enter Search mode.
2. Press the **' i '** key to activate the N001 Zhuk radar.
3. Press the **'D'** key to cycle to missiles.
4. Adjust range with the **'='** and **'-'** keys.
5. Adjust the antenna elevation up and down with the 'SHIFT-SEMI-COLON(;)' and 'SHIFT-PERIOD(.)' keys.
6. Adjust antenna azimuth left and right with the 'SHIFT-COMMA,' and 'SHIFT-FORWARD-SLASH/' keys.
7. Slew the TD Box by pressing the 'PERIOD(.)', SEMI-COLON(;)', 'COMMA(,)', and 'FORWARD-SLASH(/)' keys.

Once a target is locked in Search mode, the N001 will enter Attack mode and place the target into auto-track. In this mode, all of the radar's energy is being directed at the Target so no other targets will appear on the HUD.




1. Target aspect arrow.
2. R-MIN indicator.
3. Auto-track indicator.
4. Target range arrow.
5. R-MAX indicator.
6. Target airspeed and altitude.
7. Target marker circle.
8. 'NP Shoot cue.
9. ATTACK sub-mode HUD Indicator

In ATTACK mode the MFD will display a solid triangle target with the radar beam focused onto the target.

**To Lock and Fire on a Target with a SARH Missile:**

1. Lock on and enter ATTACK mode by pressing the **'TAB'** key as indicated by the **'A'** auto-track symbol.
2. Once in range as indicated by the **'NP'** shoot cue, press the **'SPACEBAR'** key.
3. Maintain lock for the entire duration of the missile's flight to impact.
4. Break the lock on the target by pressing the **'CTRL-TAB'** keys.

This is where one of the biggest disadvantages of the Russian radar system appears. There is no timer to indicate when the missile should have impacted or gone active so you must use other means.

The best way to determine if the missile has struck home is to watch the target aspect indicator and target altitude. You can judge by looking at the evasive maneuver's attempted by the target and by looking for the explosion and smoke trail of a burning aircraft outside. If there is no explosion and the target has maneuvered hard to beam you and is turning back in, the missile has probably missed. If the target is in a constant descent and not recovering then it has most likely been hit.

**To Lock a and Fire on a Target with a ARH Missile:**

1. Lock on and enter ATTACK mode by pressing the **'TAB'** key as indicated by the **'A'** auto-track symbol.
2. Once in range as indicated by the **'NP'** shoot cue, press the **'SPACEBAR'** key.
3. Maintain lock until the missile is within 15 kilometers of the target using the aspect and range scale.
4. Break the lock on the target by pressing the **'CTRL-TAB'** keys.

When using the infrared R-27T, R-27TE, or R-73, you can break the radar lock once you have fired the missile but will lose all target information.

# Su-27 Electro-Optical System(EOS), Schlem, and Gun Training

Welcome to Electro-Optical System(EOS), Schlem, and Gun training in the Su-27. In this tutorial you will learn how to use the Electro-Optical System, Schlem, Helmet Mounted Target Designation System, use the Gsh-301 30mm cannon, and the Vympel R-73 Archer.

This tutorial also applies to the Su-33 Naval Flanker and the Mig-29 Fulcrum.

## Electro-Optical System(EOS)

The Geophysica Electro-Optical System or EOS is a passive system that can detect and track thermally contrasting targets with high accuracy. The EOS combines a laser range finder with an Infrared Search and Track System or, IRST. The EOS sensor ball can move 15 degrees down, 60 degrees up, and 60 degrees to either side of center. The range of the EOS is from 15km for head on targets to 50km for tail on targets.

Using the EOS without the radar you can sneak up on unsuspecting targets, lock, and fire infrared missiles at them without them ever knowing. A good tactic is to use AWACS for guidance to a target and use EOS with an IR homing missile for an undetected attack.

**To use the EOS and AWACS for an Undetected Intercept:**

1. Press the **'2'** key to enter the Air to Air master mode.
2. Press the **'O'** key to activate the EOS as indicated by an **'O'** on the HUD.
3. Press the **'D'** key to cycle weapon stations to arm an infrared, R-27TE/R-27T/R-73/R-60 missile.
4. Press the **'BACKSLASH'** key, followed by the **'F5'** and **'F1'** keys to get AWACS target information.
5. Reduce closure while in EOS until the 3-dot target track appears on the HUD.
6. Slew the TD box over the track.
7. Press the **'TAB'** key to lock.
8. When in range as indicated by the **'NP'** shoot cue, press the **'SPACEBAR'** key to fire.

## Schlem, Helmet Mounted Target Designation System

The Russian Schlem targeting system, when combined with the R-73 Archer infrared dogfight missile, is one of the most lethal weapons systems in production worldwide. The Schlem system consists of a helmet mounted targeting monocle and helmet position sensors located on each side of the HUD control panel.

A small targeting circle is projected onto the pilot's monocle, which is positioned in front of the eye. The helmet position sensors monitor the movement of the helmet and these movements are then slaved to the seeker of the R-73 and the EOS. This allows the pilot to look off boresight and lock the R-73 and EOS onto the target when it is well outside the dimensions of the HUD.

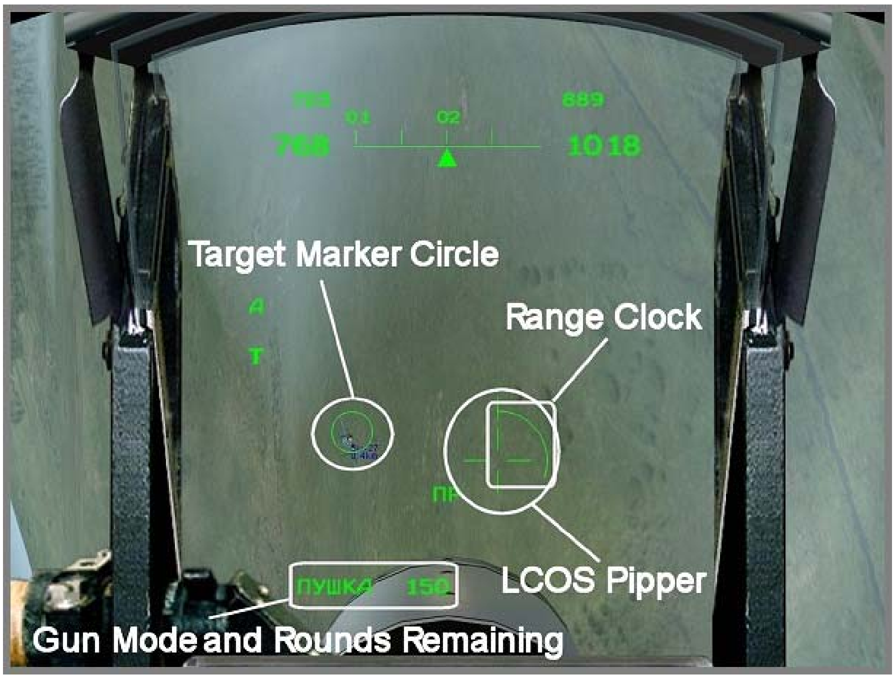
**To use the Schlem, Helmet Mounted Target Designation System and the R-73 Archer:**

1. Press the **'5'** key to activate the Schlem mode.
2. Press the **'D'** key to cycle weapon stations to arm an infrared, R-73 Archer missile.
3. Adjust your view to move the targeting circle over the target.
4. Press the **'TAB'** key to lock the seeker onto the target.
5. Ensure the **targeting circle is flashing** and the **'NP'** shoot cue is on the HUD.
6. Press the **'SPACEBAR'** key to fire.

## Gsh-301 30mm Cannon

The Gsh-301 is a 30mm rotary cannon capable of firing approximately 1500 rounds per second.  The Su-27 only carries 150 rounds but only one or two of these large caliber rounds will take out an aircraft so use them sparingly.

When the gun is selected for a target with either a radar or EOS lock the HUD will display a target marker circle over the bandit and a Lead Computing Optical Sight(LCOS) pipper.




**To use the Guns with a Locked Target:**

1. Press the **'C'** key to enter guns mode.
2. Maneuver the jet to place the cross of the LCOS pipper over the bandit.
3. When in range as indicated by the LCOS range clock, hold the **'SPACEBAR'** key to fire the gun.

When there is no target locked on, pressing the 'C' key will display the gun funnel.

# Su-27 Close Air Combat(CAC) Training

Welcome to Close Air Combat(CAC) training In the Su-27. In this tutorial you will learn how to use the Boresight and Vertical Scan Close Air Combat modes as well as the Longitudinal Missile Aiming mode to engage targets within visual range.

The Close Air Combat modes are modes that use preset radar antenna scan volumes for short range intercepts within visual range. The scanning range is from 100 meters to 15 kilometers. These modes will not automatically lock a target like the F-15C AACQ modes and you must lock the radar on the target yourself. Once the radar is locked it enters the auto-track mode until the lock is broken where it will revert back to the preset scan.

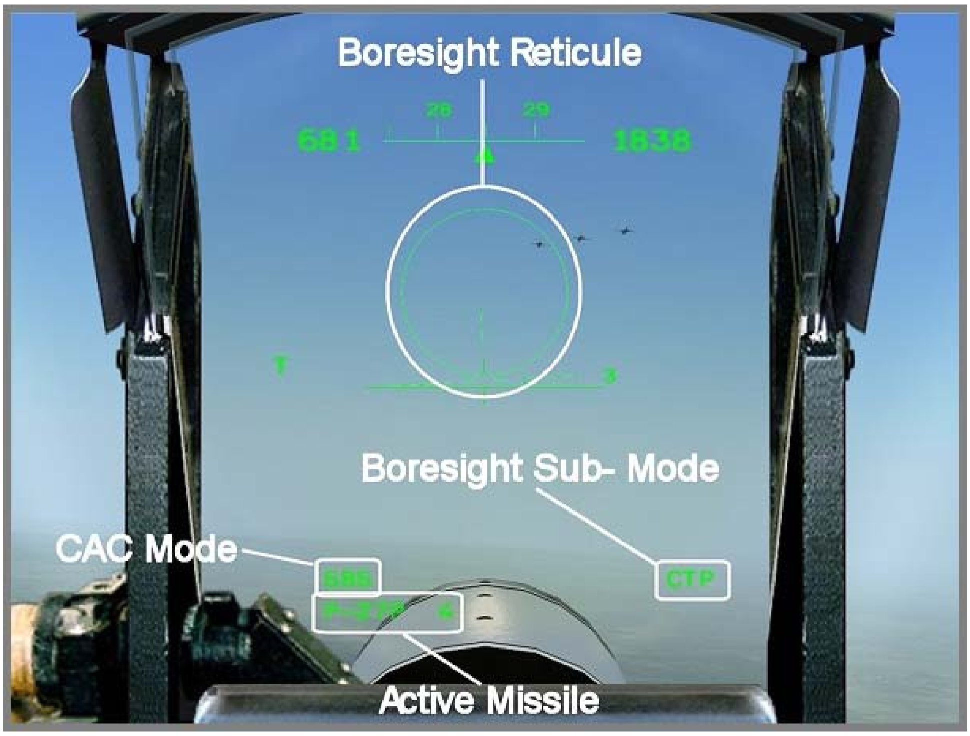
This tutorial also applies to the Su-33 Naval Flanker and the Mig-29 Fulcrum.

The Su-27 has the following 2 CAC modes:

1. Boresight Scan Mode.
2. Vertical Scan Mode.

**CAC Boresight Scan Mode**

This mode brings up a large slewable aiming reticule on the HUD and activates the EOS with the radar on stand-by. The radar scan is centered on the aircraft's boresight line and the radar will only start illuminating once a target is locked up. This mode is best for when there are a lot of aircraft in front of you and you want to select a particular one to fire at.

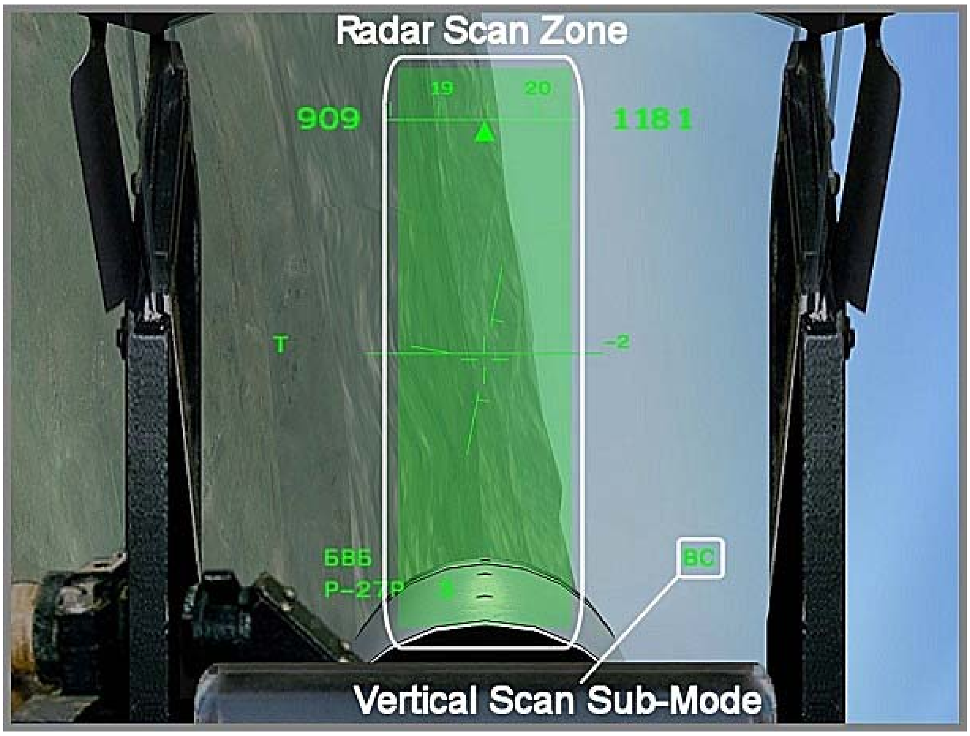



**To use the CAC Boresight Scan Mode:**

1. Press the **'4'** key to enter the Boresight Scan mode as indicated by the '**6B6**' and the '**CTP**' Scan symbols.
2. Press the **'D'** key to cycle missile stations to the missile you want to fire.
3. Maneuver the jet or slew the Boresight reticule with the '**PERIOD(.)**', **SEMI-COLON(;)**', '**COMMA(,)**', and '**FORWARD SLASH(/)**' keys to place the bandit within the reticule.
4. Press the **'TAB'** key to lock the bandit and enter the autotrack mode indicated by the **'A'** symbol on the HUD.
5. Ensure the **'NP'** shoot cue is on the HUD.
6. Press the **'SPACEBAR'** key to fire.

CAC Vertical Scan Mode

This mode displays a narrow vertical green band on the HUD, activates the EOS and puts the radar into stand-by mode and the radar will only start illuminating once a target is locked up. The radar is preset to a scan zone of 60 degrees in elevation and 25 degrees in azimuth, which extends beyond the top of the HUD. This mode is best used in a turning fight.



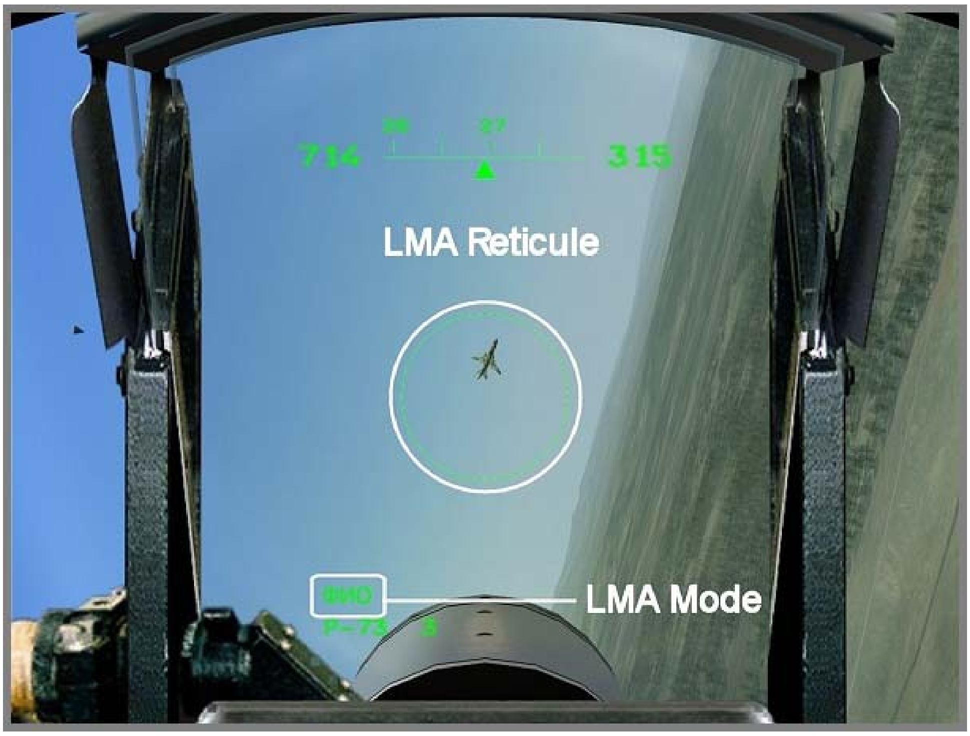

To use the CAC Boresight Scan Mode:

1. Press the **'3'** key to enter the Vertical Scan mode as indicated by the '**6B6**' and the '**BC**' Vertical Scan symbols.
2. Press the **'D'** key to cycle missile stations to the missile you want to fire.
3. Maneuver the jet to place the bandit within the green vertical scan zone or just above it.
4. Press the **'TAB'** key to lock the seeker onto the bandit.
5. Ensure the **'NP'** shoot cue is on the HUD.
6. Press the **'SPACEBAR'** key to fire.

It is important to remember that whenever you are firing a R-27R, R-27RE, or R-27EM Semi Active Radar Homing(SARH) missile, the radar lock must be maintained for the entire duration of the missile's flight to impact.

## Longitudinal Missile Aiming Mode

The Longitudinal Missile Aiming(LMA) mode uses the missiles on board seeker centered on it's boresight line and can be used with Infrared(IR) and Active Radar Homing(ARH) missiles only.  This mode is a final talon on the Flanker when you have no radar or EOS due to system failure or battle damage.




To use the Longitudinal Missile Aiming Mode:

1. Press the '6' key to enter the Longitudinal Missile Aiming mode as indicated by the '0NO' LMA symbol.
2. Press the 'D' key to cycle missile stations to the appropriate IR or ARH missile.
3. Maneuver the jet to place the bandit within the LMA seeker reticule.
4. Press the 'TAB' key to lock the seeker onto the bandit.
5. Ensure the 'NP' shoot cue is on the HUD.
6. Press the 'SPACEBAR' key to fire.

It is important to remember that the Longitudinal Missile Aiming mode cannot be used with SARH missiles.

Although there are no Auto Acquisition(AACQ) modes in the Russian jets, the EOS combined with the auto-radar activation in the CAC mode and the LMA manual mode more then make up for it by allowing a more stealthy approach to WVR combat.

# Radar Warning Receiver(RWR) Training

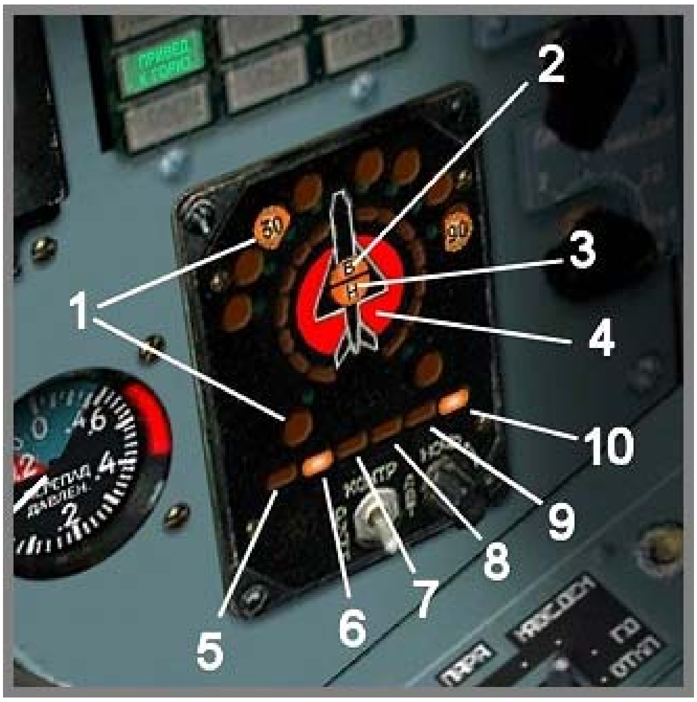
Welcome to Radar Warning Receiver(RWR) training. In this tutorial you will learn about the RWR and the information it provides to help keep you aware of the threats facing you from the air, land, and sea. The RWR receives, interprets, warns, and displays radar emitting threats to your aircraft using visual and aural warnings.

The Su-27 Flanker, Su-33 Flanker, Mig-29 Fulcrum, and Su-25 Frogfoot are all equipped with the SPO-15 Beroyza Radar Warning receiver which provide electronic detection and identification of both surface and airborne threats.

The display is oriented nose up and the 10 lights surrounding the aircraft symbol represent the bearing indicators in degrees off our nose to the threat radar emitter with the 2 arrows on the bottom only giving a general rear hemisphere bearing. The semi-circle with the 'B' in it indicates the emitter is above and 'H' indicates it is below.

The RWR display will tell you the following information::

1. The radar emitter mode, search and lock.
2. The bearing of the emitter in relation to your jet.
3. The elevation of the emitter, whether it is above or below your jet.
4. The general type of the emitter such as airborne, naval, or ground based.
5. The specific type of emitter such as a particular class of SAM based on its engagement range.




1. Emitter bearing indicators.
2. Emitter above.
3. Emitter below.
4. Lock on ring.
5. Airborne emitter.
6. Short range SAM emitter.
7. Medium range SAM emitter.
8. Long range SAM emitter.
9. Early Warning Radar.
10. AWACS.

RWR Warning Indications

The RWR will provide warnings to you via visual lights and aural tones.

- The warning for a search spike is a single tone, an emitter bearing light, and the emitter type light.
- The warning for a radar lock on is a constant tone, an emitter bearing light, and the Lock On ring light.
- The warning for a missile launch is a repetitive tone and a flashing Lock On ring.

# Su-25 Introduction and Enroute Navigation Training

Welcome to Enroute Navigation training for the Su-25. In this tutorial you will learn, in detail, about the navigation information displayed on the panel instruments, which will allow you to navigate a series of waypoints. Learning how to navigate is one of the most important skills a pilot must master. Since you are already familiar with this aircraft after completing the UPT course I won't go into detail about the instrument panel. The Su-25 has no HUD so all navigation is accomplished by using the instrument panel exclusively.

The Su-25 is powered by two Tumansky R-195 turbojet engines each rated at 4,500 Kg of thrust and is capable of reaching 970 km/h at sea level, a maximum of Mach .80 with a maximum range of 1250 kilometers, and has a ceiling of 7,000 meters.

The Su-25 uses conventional hydraulically boosted flight controls and although it's not pretty to look at, it is a fast, highly maneuverable, and dependable air to ground weapons platform.

When you start a flight and enter the cockpit you will automatically be in the enroute navigation mode.


The 6 basic flight instruments that are required to keep the aircraft in control when in cloud or at night are the following:

1. **Attitude Direction Indicator(ADI):** It is an artificial horizon that displays the aircraft's pitch and bank angles.

2. **Horizontal Situation Indicator(HSI):** Displays a horizontal, top-down view of the aircraft superimposed on a compass. The compass rotates so that the aircraft heading always appears at the top of the display.

3. **Airspeed Indicator(ASI):** shows indicated airspeed(IAS) to a maximum of 1100km/h.

4. **Barometric Altimeter:** Displays the aircraft's altitude above mean sea level at all times with a window and a sweeping pointer. The altimeter scale reads in 20 foot increments and each whole number represents 100 feet.

5. **Variometer:** Displays the aircraft's current rate of climb and rate of turn. The scale of the instrument ranges from a maximum climb of 200 meters/second to a dive of 200 meters/second. The turn rate scale ranges from 1 to 3 degrees/second to the left and right. The black ball in the glass liquid filled casing is the slip indicator and is used to coordinate turns. You would 'Step on the ball' or apply rudder to the side the ball is on to center it.

6. **Mach Meter:** Displays the aircraft speed referenced to Mach or the speed of sound. The Mach meter ranges from Mach .5 to Mach 1.0.

The Su-25 has a separate waypoint distance gauge measured in kilometers since there is no distance information displayed on the HSI.

You can cycle the waypoints by pressing the **'TILDE~'** key.

**Attitude Direction Indicator(ADI) – Integrated Flight Director**

- It is an artificial horizon, which displays the aircraft's pitch and bank attitudes. Pitch is indicated by a scrolling pitch scale and bank attitude is indicated by a small aircraft symbol that banks as the aircraft banks.
- The pitch scale is displayed in 5 degree increments with grey showing a climb and black showing a descent.
- The bank scale is graduated in 5 degree increments to 30 degrees then 15 degree increments to 60 degrees of bank.
- Integrated into the ADI is a flight director that will provide precise guidance in course and altitude to the programmed waypoint. The yellow horizontal line is the required pitch line and the yellow vertical line is the required bank line.
- The small white tick mark on the top of the ADI is the required course line and the tic mark on the left side is the required altitude line.

Keeping the yellow flight director bars crossed and each tic mark in the center will put on you the exact course at the proper altitude. It is important to remember that the pitch scale does not rotate like western ADIs and the aircraft symbol mimics your own wings.

- On the compass ring are 2 needles, the long, narrow bearing needle with the circle at the head which always points in the direction of the selected waypoint, and the short, wide needle that is always oriented to the required course to the waypoint.
- Displayed in the center of the HSI are the ILS localizer and glideslope guidance bars which are used when conducting an instrument landing.

The HSI is the primary navigation instrument and the following section will detail its functionality.

**On course:** When on course the waypoint bearing needle and the course needle will be aligned and pointing straight up.

**Course to the left:** When the required course between waypoints is to the left, the bearing needle will be pointing to the left of the course needle.

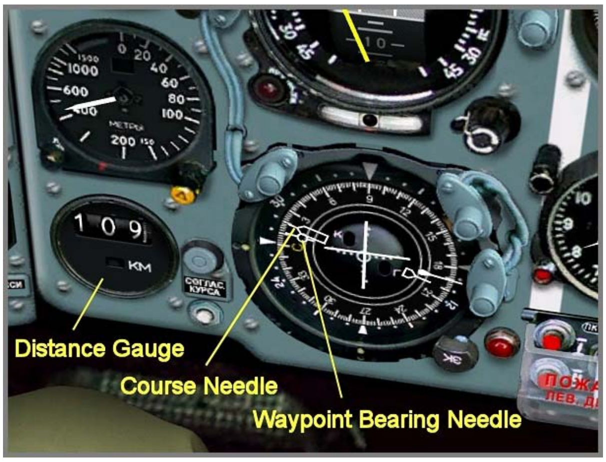
**Course to the right:** When the required course between waypoints is to the right, the bearing needle will be pointing to the right of the course needle.

To get on course you will have to intercept the required course and then turn to it's heading. Intercepts are normally at 30 and 45 degrees. The waypoint bearing needle will displaced to the side that the flight planned course is on and your intercept heading should always be to that side so always take the intercept heading off of that side of the HSI compass.

For example: You are flying on a course of 090 degrees to a waypoint. You reach the waypoint and the NAV computer automatically switches to the new course required to get to the next waypoint of 020 degrees at 109 kilometers.

The Displayed NAV information will be the following:

- The HSI course needle will be pointing left and indicating a course of '020' at the head of the needle.
- The HSI waypoint-bearing needle will be pointing left of the course needle.
- The waypoint distance gauge will indicate 109 kilometers.




To intercept the course of 020 degrees at a 30-degree intercept you find you intercept heading by subtracting the angle from the course, 020-30=350, so the intercept heading will be 350 degrees.  Fly a heading of 350 degrees until the course needle is aligned with the bearing needle then turn right to the course heading of 020.

Once on course the Displayed NAV information will be the following:

- The HSI course needle will be aligned with the bearing needle and pointing straight up indicating 020 degrees.

If the new course was to the right and the course needle and bearing needle were offset to the right you would add the intercept heading to the course.  For example, the new course is 210 and you want to intercept at a 45-degree angle.  You would add the angle to the course, 210+45=255.  Fly a heading of 255 until the course needle is aligned with the bearing needle then turn left to 210 and you are on course.

A fast and easy method to navigate to a waypoint is to simply turn the aircraft to a heading where the bearing needle is pointing straight up, then fly to it.  You won't be on the flight-planned course but you'll get there faster.

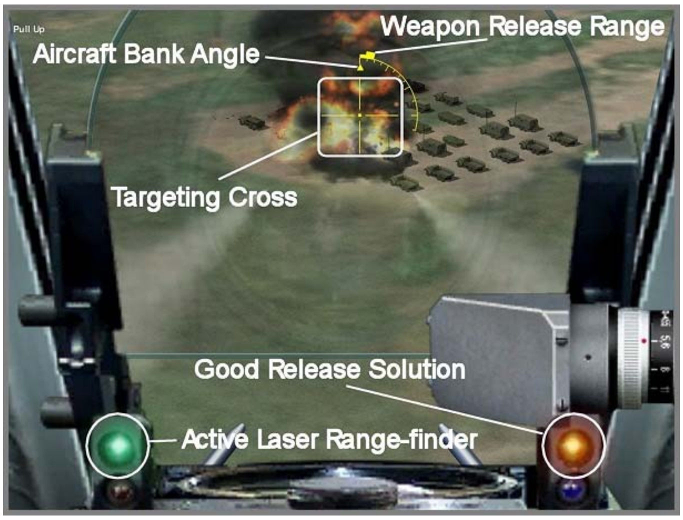
It is critical to be able to navigate properly, especially while flying in mountainous areas, which is why this training is so important.  Being off course by only a few degrees or missing required altitudes can have catastrophic consequences.

# Su-25 Gun and Rocket Training Tutorial

Welcome to cannon and unguided rockets training in the Su-25 Frogfoot. In this tutorial you will learn to use the GSh-30-2 cannon and S-8 unguided rockets.

The **GSh-30-2** is a large twin barreled 30mm cannon capable of firing 3,000 rounds per minute with a maximum ammunition capacity of 250 rounds. It is designed to destroy soft skinned and armoured vehicles.

The diagram below is the Su-25 Weapons sighting glass in the CCIP gun mode. The quarter circle around the targeting cross has an inner slant range scale with an outer arc indicating slant range of the selected weapon and a small triangle showing the bank angle of the wings of the jet. As you get closer to the ground and within range for a good firing solution, the amber light illuminates indicating that weapon release is authorized and the slant range arc starts moving counterclockwise until reaching minimum range. When the range is inside the minimum for a good firing solution, a red light will illuminate telling you to break off the attack run.




On the weapons panel the active gun is indicated by **'BNY'** with a full ammunition drum indicated by a **'K'** and the rounds remaining by either a **'1/2'**, **'1/4'**, or **'///'** which indicates the ammunition drum is empty.

Su-25 Weapons Station Panel - Gun

To use the GSh-30-2:

1. Select the GSh-30-2 cannon by pressing **'7'**, the air-to-ground weapons key.
2. Press the **'C'** key to switch to the cannon bringing up the Continuously Computed Impact Point(CCIP) gun targeting cross.
3. Press the **'O'** key to activate the laser range finder as indicated by the green light on the sighting glass.
4. Maneuver the jet to place the CCIP gun cross on the target.

5. Press the **'SPACEBAR'** key to fire the gun when in range as indicated by the amber light on the sighting glass.

The most effective attack profile for the Su-25 is a LOW-HIGH-LOW profile. Ingress to the target area at low level using the terrain to mask your position followed by a pop up to acquire and engage the target. Then dive back down and egress in a low level, high speed escape maneuver while deploying expendable countermeasures.

The Su-25 is capable of employing several different types of unguided rockets, which are listed below.

- S-8 - 80mm rockets in B-20CM pods.
- S-13 - 130mm rockets in B-13 pods
- S-24 - 240mm rockets on individual stations.
- S-25 - 250mm rockets on individual stations.

**Spetztekhnika Vympel S-8 80mm rockets** have a high explosive warhead used for anti-materiel, anti-personnel, and suppression missions. They are contained in B-20 pods.

Since the Su-25 has no HUD and the weapon sighting glass displays the targeting cross exclusively, there is no indication other then the weapon station panel of what weapon is currently selected to be released. When rockets are ready to be fired they will be indicated by a **'HPC'** on the weapon station panel. The active stations are also indicated by a green light on the stores display. You will have to know what stores are loaded on the stations when carrying different types of rockets. Writing down the stores information will be helpful.


**To use the S-8 unguided rockets:**

1. Select the S-8 rockets by pressing **'7'**, the air-to-ground weapons key.
2. Press the **'D'** key to cycle the weapon stations until the rocket CCIP targeting cross is displayed on the sighting glass. On the weapons panel rockets are indicated by a **'HPC'** symbol and the B-20 stations are indicated as active by green lights under each station on the stores display.
3. Press the **'O'** key to activate the laser range finder as indicated by the green light on the sighting glass.
4. Maneuver the jet to place the CCIP rocket cross on the target.
5. Press the **'SPACEBAR'** key to launch the rockets when in range as indicated by the amber light on the sighting glass.

The CCIP rocket targeting cross is identical to the gun cross.

# Su-25 Unguided Bomb Training Tutorial

Welcome to Unguided Bomb training for the Su-25. In this tutorial you will learn how to release unguided free-fall iron bombs and cluster munitions.  The Su-25 is capable of employing several different types of unguided bombs.  They range from general purpose, to cluster, to fuel-air, to rocket propelled concrete penetration munitions.

The unguided bombs you can use with the Su-25 are:

- FAB-250/500 - general-purpose explosive bombs.
- PB-250 - parachute retarded explosive bombs.
- ODAB-250/500 - fuel-air explosive bombs.
- ZAB-500 - fuel-oil firebombs.
- RBK-500AO - cluster bombs.
- OFAB-250/500 - concrete penetration bombs.
- SAB-100 - area illumination candle bombs.

** "250/500" denotes the weight in kilograms. **

In the Su-25 free-fall unguided bombs can have no bomb release settings and are released in pairs only.

Since the Su-25 has no HUD and the weapon sighting glass displays the targeting cross exclusively, there is no indication other then the weapon station panel of what weapon is currently selected to be released. When a pair unguided bombs is ready to be released they will be indicated by a **'6'** symbol on the weapon station panel.  The active stations are also indicated by a green light on the stores display.  You will have to know what bombs are loaded on the stations when carrying different types of unguided bombs.  Writing down the stores information will be helpful.

The unguided bomb targeting cross is identical to the gun and rocket cross.  Please refer to the gun and rocket training tutorial for a description of this system.

**To use Unguided Bombs:**

1. Select the air to ground weapon mode by pressing the **'7'** key.
2. Press the **'D'** key to cycle the weapon stations until the bombs are the selected stores as indicated on the weapons panel by a **'6'** symbol and the stations are indicated as active by green lights under each station on the stores display.
3. Press the **'O'** key to activate the laser range finder as indicated by the green light on the sighting glass.
4. Maneuver the jet to place the CCIP unguided bomb targeting cross on the target.
5. Press the **'SPACEBAR'** key to release the bombs when in range as indicated by the amber light on the sighting glass.

The Mig-29 and Su-33 can also deliver unguided bombs and rockets and use a very simple CCIP pipper and fall line system similar to the A-10A.  The 'NP' cue must be present before bombs can be released.

# Su-25 Air To Ground Tactical Missile Training

Welcome to air to ground tactical missile training for the Su-25. In this tutorial you will learn how to use the laser target designator to lock and fire air to ground tactical missiles. The Su-25 is capable of employing two different types of air to ground tactical missiles.

The tactical missiles you can use with the Su-25 are:

- KH-29L - laser guided - 317 Kg warhead.
- KH-25ML - laser guided - 90 Kg warhead.
- KH-25MP - fire and forget passive anti-radar.

The Su-25 does not have a seeker display like the A-10A's TVM so the targeting for the laser guided missiles is done visually with the Mark-1 eyeball through the weapon sighting glass. This means, with no magnification capability, you will have to get much closer to the target before you will be able to lock onto it with the laser target designator. Furthermore, you will have to maintain the laser designation for the entire flight of the missile. The KH-25MP, having a passive seeker, can be locked on a radar-emitting target from outside visual range.

The air to ground missile targeting cross is identical to the gun and rocket cross. Please refer to the gun and rocket training tutorial for a description of this system. Additionally, the air to ground missile targeting cross can be slewed on the sighting glass with the 'PERIOD(.)', 'SEMI-COLON(;)', 'COMMA(,)', and 'FORWARD SLASH(/)' keys up, down, left, and right respectively.

Since the Su-25 has no HUD and the weapon sighting glass displays the targeting cross exclusively, there is no indication other then the weapon station panel of what weapon is currently selected to be released. When an air to ground missile is ready to be released it will be indicated by a 'YP' symbol on the weapon station panel. The active stations are also indicated by a green light on the stores display. You will have to know what missiles are loaded on the stations when carrying different types of air to ground missiles. Writing down the stores information will be helpful.

**To use the KH-29L and KH-25ML Laser Guided Tactical Missiles:**

1. Select the air to ground weapon mode by pressing the '7' key.
2. Press the 'D' key to cycle the weapon stations until the air to ground missiles are the selected stores as indicated on the weapons panel by a 'YP' symbol and the KH-25ML stations are indicated as active by green lights under each station on the stores display.
3. Press the 'O' key to activate the laser range finder as indicated by the green light on the sighting glass.
4. Slew the targeting cross over the target with the 'PERIOD(.)', 'SEMI-COLON(;)', 'COMMA(,)', and 'FORWARD SLASH(/)' keys.
5. Press the 'TAB' key to lock the laser onto or near the target.
6. Press the 'SPACEBAR' key to fire the missile when in range as indicated by the amber light on the sighting glass.
7. Further slew the targeting cross to refine or change the impact point once the missile has been fired.
8. Maintain lock until the missile has impacted.

**To use the KH-25MP Passive Anti-Radar Tactical Missile:**

1. Select the air to ground weapon mode by pressing the '7' key.
2. Press the 'D' key to cycle the weapon stations until the air to ground missiles are the selected stores as indicated on the weapons panel by a 'YP' symbol and the KH-25MP stations are indicated as active by green lights under each station on the stores display.
3. Press the 'TAB' key to lock the passive seeker onto the target.
4. Press the 'SPACEBAR' key to fire the missile when in range as indicated by the amber light on the sighting glass.

# Su-25 R-60 Aphid Air To Air Missile Training

Welcome to R-60 Aphid training for the Su-25 Frogfoot. In this tutorial you will learn how to employ the R-60 infrared heat seeking air to air missile against airborne targets. The R-60 is considered a 'self defense' weapon when on the Su-25.

The Molniya R-60 Aphid is a fire and forget short-range all aspect heat seeking supersonic air to air missile. Because the Su-25 has no air-to-air radar to help acquire targets you will be depending on eyesight to both locate and lock the R-60's infrared seeker on the target. R-60 Aphid missiles can only be carried on the 1 and 10 stations.

The air to air targeting cross is identical to the gun and rocket cross. Please refer to the gun and rocket training tutorial for a description of this system.

Since the Su-25 has no HUD and the weapon sighting glass displays the targeting cross exclusively, there is no indication other then the weapon station panel of what weapon is currently selected to be released. When an air to air R-60 missile is ready to be fired it will be indicated by a **'YP'** symbol on the weapon station panel. The active stations, 1 and 10, are also indicated by a green light on the stores display.

**To use the R-60 Aphid Missile:**

1. Select the air to air weapon mode by pressing the **'6'** key. This will automatically select the R-60 stations as indicated on the weapons panel by a **'YP'** symbol and the R-60 stations are indicated as active by green lights under each station on the stores display.
2. Maneuver the jet to place the targeting cross near the target.
3. Press the **'TAB'** key to lock the missile onto the target as indicated by the cross tracking the target.
4. Press the **'SPACEBAR'** key to fire the missile when in range as indicated by the amber light on the sighting glass.

# Fighter Weapons School – Pursuit Geometry

Welcome to Fighter Weapons School and your first Basic Fighter Maneuver or 'BFM' lesson, pursuit geometry. In this tutorial you will learn about attack geometry and the three different pursuit courses, Lead, Pure, and Lag Pursuit and when to use them during a dogfight.

## Lead Pursuit

The first is pursuit course is 'Lead Pursuit' which is when you place your nose and velocity vector ahead of the bandit's. It is used to close the distance and effectively cut off the bandit's path in the sky. You would use lead pursuit when you have an energy advantage and are trying to bring the bandit into the HUD for a guns shot.

Using Lead pursuit against a fighter with similar or better turn characteristics is not wise since you will drain your energy trying to keep your nose ahead of his. You do have to be careful that you don't overshoot though.

**Lead pursuit is executed by placing your Velocity Vector(VV) out in front of the bandit.**

## Pure Pursuit

The next pursuit course is 'Pure Pursuit', which is a pursuit course where your velocity vector is on the bandit. With a pure pursuit course you will increase closure and reduce the distance to the bandit. Pure pursuit is best used when shooting missiles. Again, be aware that a pure pursuit course can lead to a collision or overshoot if followed long enough.

**Pure pursuit is executed by placing your Velocity Vector on the bandit.**

## Lag Pursuit

The final pursuit course is 'Lag Pursuit', which is when you place your velocity vector behind the bandit and 'lag' behind his flight path. This is the best course to fly when approaching the bandit or trying to reduce closure and the angle off his tail in order to get into a good low aspect position behind him.

You must be able to out turn the bandit when using lag pursuit in order to switch to lead pursuit to bring him into the HUD for a shot.

**Lag pursuit is executed by placing your Velocity Vector behind the bandit.**

Lag pursuit is also used when making out of plane maneuvers like yo-yo's but more on that in the next training tutorial.

# Fighter Weapons School – Lead Turns

Welcome to your second BFM lesson, Lead Turns. A lead turn is an offensive maneuver, think of a lead turn as an 'early' turn toward an opponent who is approaching nose on.

**To Perform a Lead Turn:**

1. Turn into him in a nose low slice. A slightly out-of-plane turn is best so they will pass either above or below you
2. Continue maneuvering through the bandit's six and into a lag pursuit position.
3. Reel the bandit in for a good gun or missile shot.

**Some of the dangers of a poorly executed lead turn:**

1. Timing is critical, the earlier you start the turn the better the position you'll end up in but starting it too early can be extremely dangerous because you'll pass in front of your adversary's nose risking a possible collision or a guns snapshot.
2. You'll likely lose sight of him in the turn as the bandit drops under your own nose. If you are starting early then roll slightly out-of-plane so that he'll pass either above or below you and with an out of plane maneuver you can prevent a guns snapshot by the bandit.
3. By starting the turn too late you might find yourself crossing his flight path at nearly 90 degrees in an overshoot and you will not be in a good position to finish with a kill.

# Fighter Weapons School – Single Circle Fight

Welcome to the third in the series of BFM training missions, the single circle fight. In this tutorial you will learn about the single circle fight and when it's best to use it merging for a dogfight.

The single circle or 'nose to nose' is one where both aircraft are maneuvering within the same circle and is best used in a low separation merge when the bandit has a higher speed, you have a turn radius advantage, and you are just above corner velocity.

Corner velocity is the speed which will give the aircraft the best turn rate with the smallest turn radius and is about 375 knots in the F-15C Eagle and 720 km/h in the Su-27 Flanker.

**To Execute a Merge for a Single Circle Fight:**

1. Merge at or close to corner velocity with low separation and a lower speed then the bandit.
2. Make a hard sustained turn away from the bandit.
3. Continue the hard turn to ensure you are making a much smaller turn radius then the bandit.
4. Reverse the turn into a lag pursuit position while maintaining energy.
5. Close for a kill.

When the bandit has a much greater speed at the merge he will make a much larger circle and you will be able to turn inside of him and reverse back to bring your nose on to him for a close range missile shot. One thing to remember about initiating a single circle fight is that you will lose sight of the bandit momentarily so be sure you know where to look when he comes back into view and once you start the turn don't reverse it until the time is right.

# Fighter Weapons School – Two Circle Fight

Welcome to the fourth in the series of BFM training missions, the two-circle fight. In this tutorial you will learn about the two-circle fight and when it's best to use it merging for a dogfight.

The two-circle or 'nose to tail' is one where both aircraft are maneuvering within their own separate but adjoining circles. It is initiated by a lead turn into the bandit and is best used when you have a turn rate advantage and all aspect missiles since initiating the two circle fight with a lead turn may help you quickly get your nose on the bandit for a missile shot.

It is a good idea to get some flight path separation with the bandit before them merge by turning away from him briefly.

**To Execute a Merge for a Two Circle Fight:**

1. Merge at or close to the same speed as the bandit with some flight path separation.
2. Turn into him with a hard slicing lead turn.
3. Use your turn rate advantage to bring him onto your nose using pure, lead, and lag pursuit.
4. Close for a kill.

Using a turn rate advantage with some initial separation and a good hard lead turn will easily bring your missiles to bear on a slower turning bandit. Expect most merges with fighters to lead to two circle fights and once you start the lead turn don't reverse it.

# *Fighter Weapons School – Yo-Yos*

Welcome to your final BFM training mission, the Yo-yo. The training tutorial on lead, pure, and lag pursuit is a prerequisite for this one. If you don't understand those concepts the yo-yo will be more difficult to understand.

There are two types of yo-yo maneuvers. The high and low. The high yo-yo is designed to slow closure with your target and lower the aspect angle to help place you more directly behind him. The low yo-yo has just the opposite effect, its primary purpose is to increase the rate of closure on the target.

### High Yo-Yo

A high yo-yo uses three dimensional maneuvering to place you behind your target but use it in situations where your angle off the target's tail is about 30-60 degrees and you are not in lead pursuit.

Imagine that you are in pure pursuit and are in the same plane of maneuver as your adversary. As you close he begins a turn into you. If you try to turn with him, you will most likely overshoot. Instead, perform a high yo-yo. Roll wings level and pull up out of his plane of turn. This climb and separation will reduce the rate of closure. Then roll toward bandit and place your lift vector either behind, on, or ahead him depending on whether you want establish lag, pure, or lead pursuit.

**To perform a High Yo-Yo:**

1. Roll the wings level and start a climb to a position above and outside of the bandit’s turning circle.
2. Roll back into the bandit in a dive and maneuver into a lag pursuit position as you close on them.
3. Reduce closure and increase the lag pursuit course.
4. Continue reducing closure to position for a missile shot.

### Low Yo-Yo

While a high yo-yo is designed to reduce the rate of closure during an attack the low yo-yo is designed for just the opposite. It increases the rate of closure and just like the high yo-yo, it's an out-of-plane maneuver. The low yo-yo is useful in a situation where you are not overtaking the bandit and can't turn sharply enough to pull your nose onto him.

**To perform a Low Yo-Yo:**

1. Pull your nose down toward the inside of the bandit's circle and roll the wings level. This will give you a useful gravity assist that would be far more important if the range was fairly large. By rolling a bit in a nose low attitude, you can actually cut across the inside of his circle in lead pursuit.
2. Pulling your nose up to reduce the range put your weapons on target.

The greater the range between the attacker and defender the better it is to use two smaller yo-yo's, either high or low, than a single large one. The more time it takes to complete the maneuver the more time the defender has to counter it.

# *Beyond Visual Range Intercept Training*

Welcome to Beyond Visual Range(BVR) Intercept training. In this tutorial you will learn tactics and procedures on getting the best advantage possible during a BVR engagement. Using a hypothetical intercept with 4 Su-27 Flankers on 3 F/A-18 Hornet's the intercept would be as follows.

A tactical BVR Intercept consists of the following 6 steps:

1. Detection.
2. Sorting.
3. Targeting.
4. Intercept.
5. Engage.
6. Separate.

Contact, there is the group at approximately 90 km, the detection step is complete. Now before you can lock your sensors on to the bandits you want to set up for the best possible merge. Start by tightening the formation so your flight looks like one aircraft on the enemy's radar. Now start climbing and increasing speed because when you launch your missiles you want to be going as fast as possible to help get your missiles to the enemy before his missiles get to you. This is called, 'F-POLE' which is defined as, the shooter to target distance at missile impact and the advantage is to always have a greater F-POLE then your adversary. When shooting active radar guided missiles the term is 'A-POLE' and is the distance when the missile's seeker goes active and you can unsupport it and go defensive on an incoming missile.

As your distance closes it's time to sort the bandits. Looks like at least 3 head on in trail formation and offensive. Target the lead Hornet and you want your wingmen to break off and pince the Hornets to cause them to separate. Give the command ordering Wingman 2 and 3 to split left and you and your wingman continue straight ahead. This will start a horizontal bracketing intercept of the Hornets, which will hopefully get them to focus on the two jets splitting left. You and your wingman level off and continue to increase speed. By climbing to a higher altitude the missile you launch will travel faster in the less dense air and can use a dive in the terminal phase of flight to help it get to the target even quicker. The Hornets are splitting in trail so now that you have them sorted it's time to target them. Order wingman 2 and 3 to attack the lead Hornets, while wingman 1 and yourself break right and target the two trailing bandits. Ok, now that you have the bandits targeted and your bracket is set up it's time to engage!

Your wingman has his target, your target is locked and there is R-MAX. Alamo away! There goes the R-27RE. Now that you have fired you want to slow as quickly as possible to again, increase your F-POLE. The speedbrake is out and now 'CRANK' or offset to the right and place the bandit on your front left quarter while still maintaining lock. This increases F-POLE. He probably has a missile at you now so you will see who has the greatest F-POLE. The aspect indicator is showing a beam maneuver, he's defensive. Now you forced him to break his lock and Boom! There's the impact! Splash 1! Let's hope your wingmen were as fortunate. Now you are merged and are looking for bandits to mop up with Close Air Combat modes. Splash 2 and it looks like your wingman did their jobs by downing the other 2 Hornets. You'll now separate from this engagement at maximum speed.

The above is a general description of how to use your wingmen effectively in a multi-ship BVR intercept.

Always remember the 6 steps of a Beyond Visual Range tactical intercept, detection, sorting, targeting, intercept, engage, and separate.

# AWACS Intercept and GCI Datalink Training

Welcome to Airborne Warning and Control System(AWACS) training. In this tutorial you will learn how to communicate with the Boeing E-3 Sentry AWACS aircraft for guidance to intercept enemy aircraft. Additionally, you will learn about the AWACS and GCI datalink available on the Su-27, Su-33, and Mig-29.

The E-3 Sentry is a modified Boeing 707 commercial airliner with a rotating radar dome. The dome is 30 feet in diameter, six feet thick, and is held 14 feet above the fuselage by two struts. It contains a radar subsystem that permits surveillance from the Earth's surface up into the stratosphere, over land or water. The radar has a range of more than 250 miles for low-flying targets and farther for aerospace vehicles flying at medium to high altitudes. The radar combined with an identification friend or foe(IFF) subsystem can look down to detect, identify, and track enemy and friendly low-flying aircraft

This tutorial also applies to the E-2 Hawkeye and the Russian A-50 Mainstay AWACS aircraft.


AWACS threat information is given in **BRAA** format; **B**earing to the aircraft, **R**ange, **A**ltitude(LOW, MEDIUM, or HIGH), and **A**spect, **'HOT'** which is nose on, **'COLD'** which is tail on, and **'FLANKING'** which is a beam aspect. If enemy aircraft are within five miles of you then a **'MERGED'** call is given. If the AWACS controller detects no threat, a **'CLEAN'** response is given.

AWACS threat information is given in **BRAA** format; **B**earing to the aircraft, **R**ange, **A**ltitude(LOW, MEDIUM, or HIGH), and **A**spect, **'HOT'** which is nose on, **'COLD'** which is tail on, and **'FLANKING'** which is a beam aspect. If enemy aircraft are within five miles of player then a **'MERGED'** call is given. If the AWACS controller detects no threat, a **'CLEAN'** response is given.

**To use the AWACS to Intercept Enemy Aircraft:**

1. Press the **'BACKSLASH'** key followed by the **'F5'** and **'F1'** keys to get information on your nearest threat.
2. Turn and climb or descend to intercept the target as per the AWACS controller's BRAA call.
3. Try to approach the target doing your best to remain undetected.
4. Activate your radar in Search or Track While Scan mode, or just activate the EOS if applicable.
5. Once you find the target, intercept.

If you are illuminating a target in the distance but too far for the NCTR or IFF to identify if it is a friend or foe, you can get assistance from an AWACS controller.

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**To use the AWACS to Identify an Unknown Aircraft:**

1. Place a target aircraft into STT lock or bugged in TWS.
2. Press the **'BACKSLASH'** key followed by the **'F5'** and **'F4'** keys to have the AWACS controller, **'DECLARE'**.

AWACS will respond with either **'FRIENDLY'** or **'HOSTILE'**.

If a new threat appears on the AWACS controller's scope, a flight just taking off for example, a **'POP UP GROUP'** call with BRAA information is given automatically.

**Russian AWACS and GCI Datalink**

Cold war Russian intercept doctrine has always been to use large numbers of capable aircraft controlled by AWACS and Ground Control Intercept(GCI) controllers to position the interceptors to create the best chance to achieve a successful outcome in the skies.  The Russian technology even goes as far as allowing the intercept controller to control the aircraft via its autopilot.

The information is passed to the interceptor via an encrypted radio datalink.  Through this datalink, the controller can display headings, altitudes, and speeds on the HUD for the pilot to follow to complete the intercept.

In Lock On, the AWACS and GCI display the aircraft they are illuminating via a datalink to the Flanker and Fulcrum MFD.  This information is only for situational awareness purposes and no sensors or weapons can be locked on and guided by the AWACS or EWR station.  Hostile contacts are indicated by triangles and friendlies by circles.

The AWACS and EWR Units are the following:

- A-50 Mainstay AWACS.
- 1L13 Long-range mobile surveillance radar.
- 55G6 Long-range air detection radar.

**To use the AWACS and EWR Datalink:**

1. Ensure an AWACS or EWR station is active in the mission.
2. Press the **'2'** key to enter the air to air Search mode.
3. Press the **'O'** key to activate the EOS and AWACS datalink display.
4. Leave your radar off and intercept a datalinked target using the EOS system only.
5. Activate your radar once within R-MAX if required.
6. Engage the target.

# F-15C Air to Air Refueling Training

Welcome to Air to Air Refueling training in the F-15C. In this tutorial you will learn how to communicate with the Boeing KC-10A aerial tanker and hook up to the refueling boom to top off your tanks. This is one of the most difficult tasks to master as an F-15 pilot.

The KC-10A is heavily modified DC-10 aircraft that is literally a flying fuel tank. The KC-10 has a long fueling boom that extends from behind the jet. The F-15C and the A-10A have refueling receptacles and the controller flies the boom into receptacle. The F-15C has its receptacle located in the left wing root and the A-10A has it in the nose.

You will be able to get the location of the KC-10A from AWACS and the tanker will give you directions once you are close enough.


**To Connect to the KC-10A to Receive Fuel:**

1. Press the **'BACKSLASH'** key followed by the **'F5'** and **'F3'** keys to get the location of the tanker from AWACS.
2. Activate RWS mode and the radar to locate and lock onto the tanker to get it's distance, altitude, and speed.
3. Maneuver the jet within 2 miles, co-altitude, and in trail of the KC-10A.
4. Press the **'R'** key extend the refueling probe.
5. Press the **'1'** key to switch to the NAV mode. Once within 1 mile from the KC-10 the HUD will switch to the re-fueling mode as indicated on the NAV block. This will also alert the KC-10A to extend its boom.
6. Approach the boom and descend to 30 feet below the altitude of the KC-10A.
7. Use the altitude hold function as required by pressing the **'H'** key.
8. When within 200 feet of the KC-10A ensure your speed is only 2-5 knots faster then the tanker.
9. Press the **'J'** key to activate the auto-throttles and continue to fly to the boom.

Once you have connected to the boom the autopilot will engage automatically and you can relax as the fuel is loaded.

**To Disconnect from the Boom:**

1. Move the thrust levers to the idle gate.
2. Press the **'R'** key to end the fueling.
3. Press the **'A'** then **'J'** keys to disconnect the autopilot and auto-throttle.
4. Smoothly slip away from the boom and once clear turn away from the tanker. Use the speedbrake if required.

Be proud of the fact you have just completed one of the most difficult tasks facing a combat pilot!

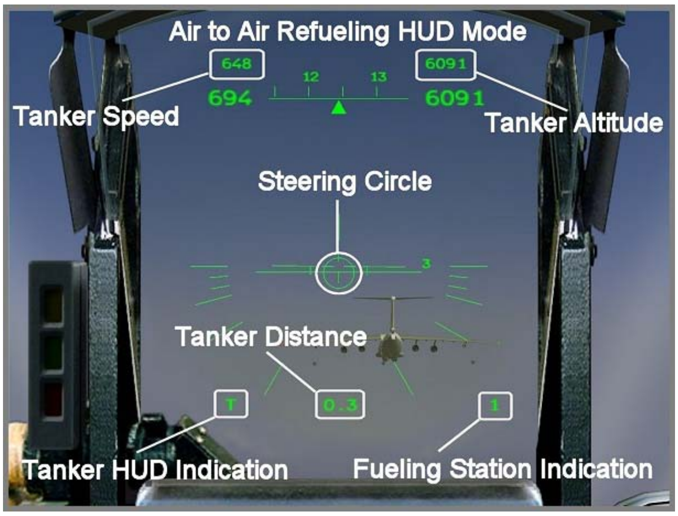
# *Su-33 Air to Air Refueling Training*

Welcome to air to air refueling training in the Su-33 Naval Flanker. In this tutorial you learn how to communicate with the IL-78 Midas aerial tanker and hook up to a refueling basket to top off your tanks. This is one of the most difficult tasks to master as a Flanker pilot.

The Russian air to air refueling system uses a basket and probe. The Il-78 will extend large baskets attached to thick fuel lines behind the jet from 3 different stations. The baskets are attached to fuel tanks on each wing and on the left side of the tail. The Su-33 has a refueling probe in the left side of the nose that is extended and you will have to fly the probe into the basket to make a connection to receive fuel.

You can cycle the fuel stations to chose which one you want to refuel from. The station on the left wing is #1. The station on the left side of the tail is #2. The station on the right wing is #3.

You will be able to get the location of the IL-78 from AWACS and the tanker will give you directions once you are close enough.




**To Connect to the IL-78 to Receive Fuel:**

1. Press the '**BACKSLASH**' key followed by the '**F5**' and '**F3**' keys to get the location of the tanker from AWACS.
2. Activate Search mode and the radar to locate and lock onto the tanker to get it's distance, altitude, and speed.
3. Maneuver the jet within 5 kilometers, co-altitude, and in trail of the IL-78.
4. Press the '**R**' key extend the refueling probe.
5. Press the '**1**' key to switch to the NAV mode. Once within 1.2 kilometers from the IL-78 the HUD will switch to the re-fueling mode as indicated on the bottom left by a '**T**'. This will also alert the IL-78 to extend its baskets.
6. Select which basket you want to refuel from by pressing the '**TILDE**' key as indicated on the bottom right of the HUD.
7. Approach the basket by keeping the aircraft datum centered in the steering circle and monitor the tanker speed and altitude indications.
8. Use the altitude hold autopilot function as required by pressing the '**H**' key.
9. When within a 50 meters of the IL-78 ensure your speed is only 2-5 km/h faster then the tanker.
10. Press the '**J**' key to activate the auto-throttles and continue to fly to the basket.

Once you have connected to the basket the autopilot will engage automatically and you can relax as the fuel is loaded.

To Disconnect from the Basket:

1. Move the thrust levers to the idle gate.
2. Press the 'R' key to end the fueling.
3. Press the 'A' then 'J' keys to disconnect the autopilot and auto-throttle.
4. Smoothly slip away from the basket and once clear turn away from the tanker. Use the speedbrake if required.

# Su-33 Carrier Qualification Training

Welcome to carrier qualification training in the Su-33 Naval Flanker. In this tutorial you learn how to navigate to the aircraft carrier, execute an ILS approach to a landing, and then take off from the bow ramp of the Admiral Kuznetsov.

The Su-33 Flanker is a naval variant of the Su-27 with some very unique features. It has more powerful engines, folding wings and tailerons, stronger landing gear with dual nosewheel, an arresting cable hook, an in-flight refueling probe, and a shortened tail stinger. The Su-33 can also employ dumb bombs and rockets fulfilling a basic air to ground combat role.

The Admiral Kuznetsov is a type 1143.5 heavy aircraft carrying cruiser with a displacement of 67,500 tons when fully loaded. It has four arresting cables and 4 aircraft launching stations. It does not have a steam driven catapult system like western carriers and uses the thrust of the aircraft's engines and a ramp on the bow to create the necessary speed and lift for the aircraft to take off successfully.

## Navigating to the Ship

Navigating to the ship is the same as navigating to an airport. You follow the same steps but instead of selecting the airport on the MFD, you select the ship.

**To Navigate to the Kuznetsov:**

1. Press the **'1'** key to cycle navigation modes until **'B03P'** appears as the sub-mode on the HUD.
2. Turn the jet so the HUD steering circle is centered over the aircraft datum and the waypoint bearing needle is pointing up. This will give you a direct route to the IAF.
3. Climb or descend as required by the waypoint altitude information on the top right of the HUD.
4. 5 km from the IAF you should be slowed to about **400 km/h**. Extend the approach flaps by pressing the **'F'** key.
5. Extend the hook by pressing the **'CTRL-G'** keys and note the indication on the aircraft configuration panel.
6. Continue to the IAF and the NAV computer will automatically select the ILS mode when you are within range.

**To perform an ILS Approach and Landing on the Kuznetsov:**

1. At this point in the approach you will be in the ILS mode as shown by the **'NOC'** sub-mode on the HUD.
2. At glideslope intercept extend the landing gear by pressing the **'G'** key and turn on the landing lights with 2 presses of the **'ALT-L'** keys.
3. Increase thrust to about **80% N1** to maintain **330-350 km/h.**
4. Confirm 3 Green and set landing flaps by pressing the **'SHIFT-F'** keys.
5. Increase thrust to about **85% N1**.
6. Remain on the localizer and glideslope by following the steering circle.
7. Maintain a **5 m/s** descent rate and **310-330 km/h** down the glideslope.
8. Once visual and on short final to the deck, reduce speed to cross the end of the deck at **280 km/h.**
9. **Do Not Flare!** Maintain the same descent rate and plant the jet onto the deck.
10. Once the mains touch, increase thrust to full afterburner and be prepared to bolter and take off again.
11. If you catch an arresting cable it will stop you.

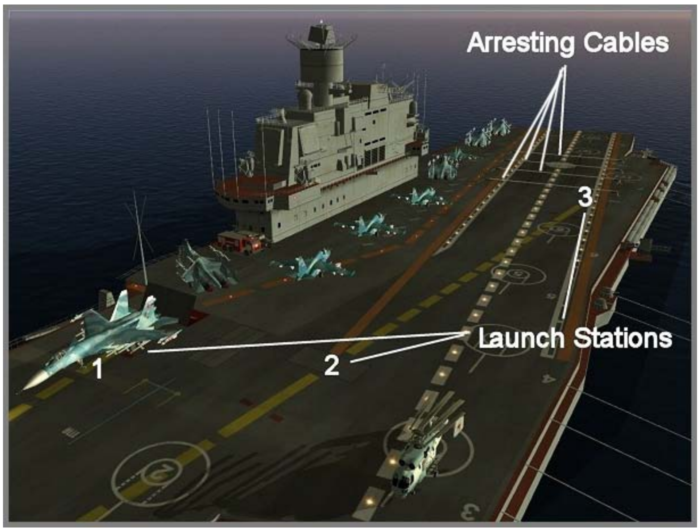
Once you have come safely to a stop you can taxi to a parking area on the ship or to a launch station.

**Bolter!**

In the event you do not catch a wire you must bolter!
1. Pitch nose up to **10 degrees**.
2. At positive rate on the variometer, raise the landing gear.
3. Once the gear is up, raise the flaps to the approach setting.
4. Continue climb to at least **1000 meters** above ground and then return to the IP for another approach.

**To Taxi to and Take Off from a Launch Station:**

1. Fold the wings with the **'CTRL-P'** keys. Raise the flaps with the **'CTRL-F'** keys and the hook with the **'CTRL-G'** keys.
2. Taxi slowly to a designated launch station.
3. Come to a stop with the jet completely ahead of the blast shield.
4. Press the **'U'** key to raise the wheel chokes and the blast shield.
5. Lower the wings by pressing the **'CTRL-P'** keys again.
6. Lower the flaps to the landing setting by pressing the **'SHIFT-F''** keys.
7. Pull the flightstick fully back and hold it.
8. Increase thrust to full afterburner.
9. When the wheel chokes release you continue straight off the ramp.
10. Once you have cleared the ramp, raise the gear with the **'G'** key and maintain 15 degrees of pitch.
11. As you increase altitude, start reducing pitch to increase speed.
12. When you at **100 meters** above the water raise the flaps to the approach setting by pressing the **'F'** key.
13. When you are climbing out at a normal speed, raise the flaps fully by pressing the **'CTRL-F'** keys.



# Recognition Charts

## Air (Fixed Wing)

## Recognition Charts

# Recognition Charts

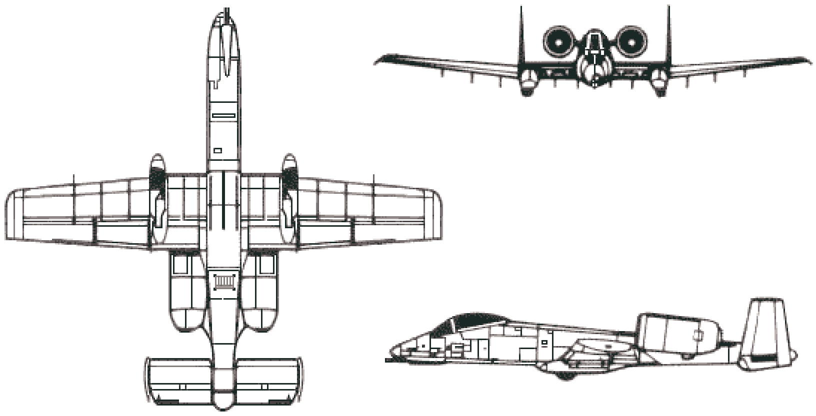
# Recognition Charts

# Recognition Charts

# A-10A "Thunderbolt II"

**Type: Attack Aircraft**

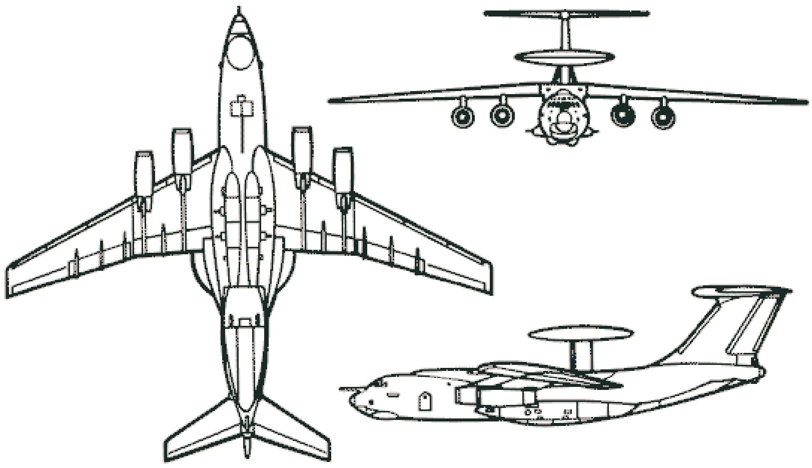
Crew: 1
Length: 16.26 m
Height: 4.47 m
Wing span: 17.53 m
Wing area: 47 sq m
Weight empty: 9389 kg
Normal weight: 11500 kg
Maximum weight: 21081 kg
Maximum fuel: 4853 kg
Service ceiling: 10000 m
Take-off speed: 223.2 km/h
Landing speed: 244.8 km/h
Maximum Mach at S/L: 0.75
Maximum Mach at height: 0.75
G limit: 5.9
Range with nominal load: 1500 km
Maximum range: 1500 km



# A-50 "Mainstay"

**Type: AWACS**

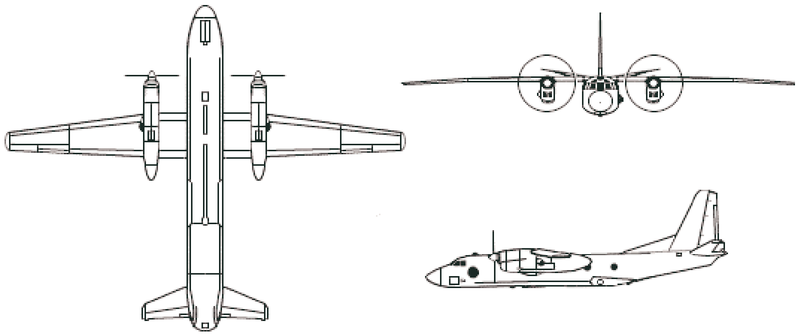
Crew: 10
Length: 46.59 m
Height: 14.76 m
Wing span: 50.5 m
Wing area: 300 sq m
Weight empty: 90000 kg
Normal weight: 160000 kg
Maximum weight: 190000 kg
Maximum fuel: 70000 kg
Service ceiling: 12247 m
Take-off speed: 208.8 km/h
Landing speed: 219.6 km/h
Maximum Mach at S/L: 0.77
Maximum Mach at height: 0.77
G limit: 2.5
Range with nominal load: 7300 km
Maximum range: 7300 km



## An-26B "Curl-A"

***Type: Medium-range Transport***

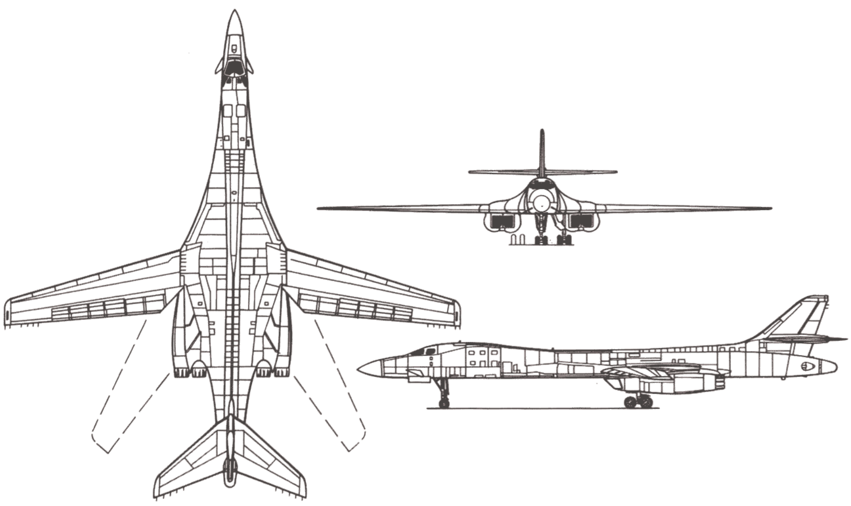
Crew: 5
Length: 23.8 m
Height: 8.575 m
Wing span: 29.2 m
Wing area: 75 sq m
Weight empty: 15850 kg
Normal weight: 23000 kg
Maximum weight: 24000 kg
Maximum fuel: 5500 kg
Service ceiling: 7500 m
Take-off speed: 216 km/h
Landing speed: 190.08 km/h
Maximum Mach at S/L: 0.55
Maximum Mach at height: 0.55
G limit: 2.5
Range with nominal load: 2660 km
Maximum range: 2660 km



## B-1B "Lancer"

***Type: Strategic Heavy Bomber***

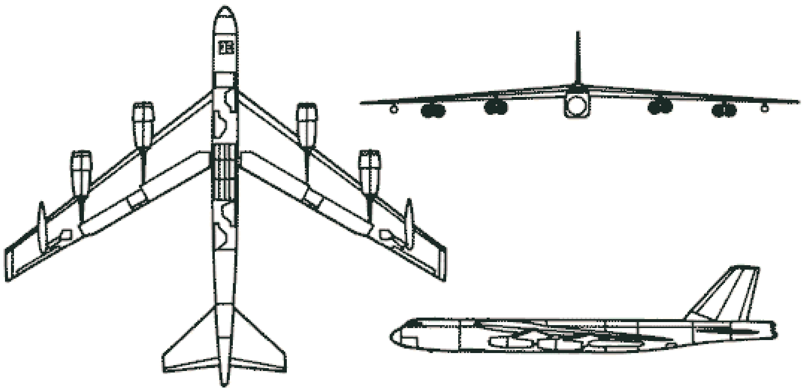
Crew: 4
Length: 44.81 m
Height: 10.36 m
Wing span: 41.67 m
Wing area: 181 sq m
Weight empty: 87090 kg
Normal weight: 140000 kg
Maximum weight: 216360 kg
Maximum fuel: 88450 kg
Service ceiling: 12300 m
Take-off speed: 284.4 km/h
Landing speed: 280.8 km/h
Maximum Mach at S/L: 1.08
Maximum Mach at height: 1.68
G limit: 3.5
Range with nominal load: 12000 km
Maximum range: 12000 km



# B-52 "Stratofortress"

**Type: Strategic Heavy Bomber**

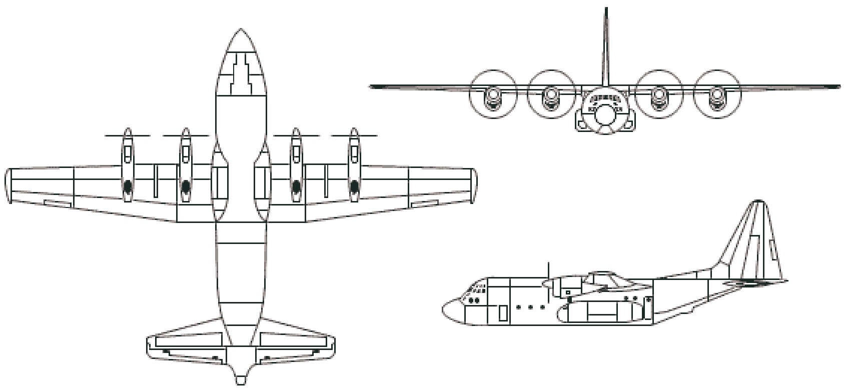
Crew: 4
Length: 49.05 m
Height: 12.4 m
Wing span: 56.4 m
Wing area: 371 sq m
Weight empty: 83460 kg
Normal weight: 200000 kg
Maximum weight: 256735 kg
Maximum fuel: 141135 kg
Service ceiling: 16764 m
Take-off speed: 234 km/h
Landing speed: 234 km/h
Maximum Mach at S/L: 0.53
Maximum Mach at height: 0.95
G limit: 2.5
Range with nominal load: 16700 km
Maximum range: 16700 km



# C-130 "Hercules"

**Type: Tactical Transport**

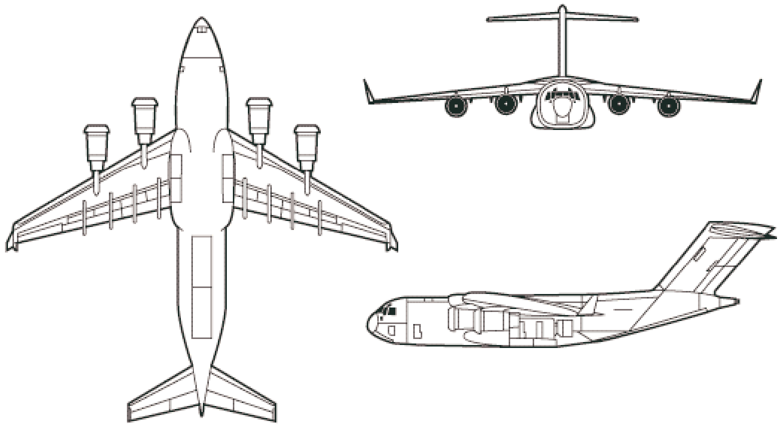
Crew: 2
Length: 29.79 m
Height: 11.66 m
Wing span: 40.4 m
Wing area: 162 sq m
Weight empty: 36400 kg
Normal weight: 70000 kg
Maximum weight: 79380 kg
Maximum fuel: 20830 kg
Service ceiling: 9315 m
Take-off speed: 208.8 km/h
Landing speed: 219.6 km/h
Maximum Mach at S/L: 0.55
Maximum Mach at height: 0.55
G limit: 2.5
Range with nominal load: 8260 km
Maximum range: 8260 km



# C-17A "Globemaster III"

***Type: Long-Range Transport***

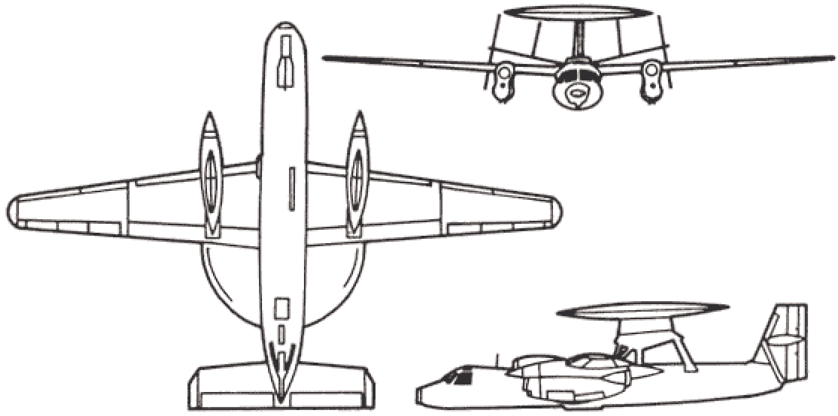
Crew: 2
Length: 53.04 m
Height: 16.79 m
Wing span: 51.76 m
Wing area: 353 sq m
Weight empty: 125645 kg
Normal weight: 193000 kg
Maximum weight: 265350 kg
Maximum fuel: 132405 kg
Service ceiling: 13715 m
Take-off speed: 216 km/h
Landing speed: 216 km/h
Maximum Mach at S/L: 0.56
Maximum Mach at height: 0.56
G limit: 2.5
Range with nominal load: 12993 km
Maximum range: 12993 km



# E-2C "Hawkeye"

***Type: AWACS***

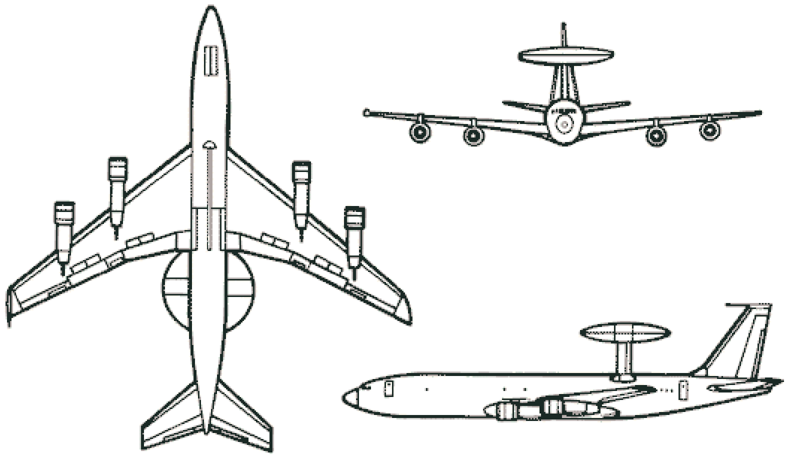
Crew: 5
Length: 17.55 m
Height: 5.59 m
Wing span: 24.56 m
Wing area: 65.03 sq m
Weight empty: 17090 kg
Normal weight: 20500 kg
Maximum weight: 24687 kg
Maximum fuel: 5624 kg
Service ceiling: 11275 m
Take-off speed: 190.8 km/h
Landing speed: 190.8 km/h
Maximum Mach at S/L: 0.53
Maximum Mach at height: 0.53
G limit: 2.5
Range with nominal load: 2854 km
Maximum range: 2854 km



# E-3 "Sentry"

***Type: AWACS***

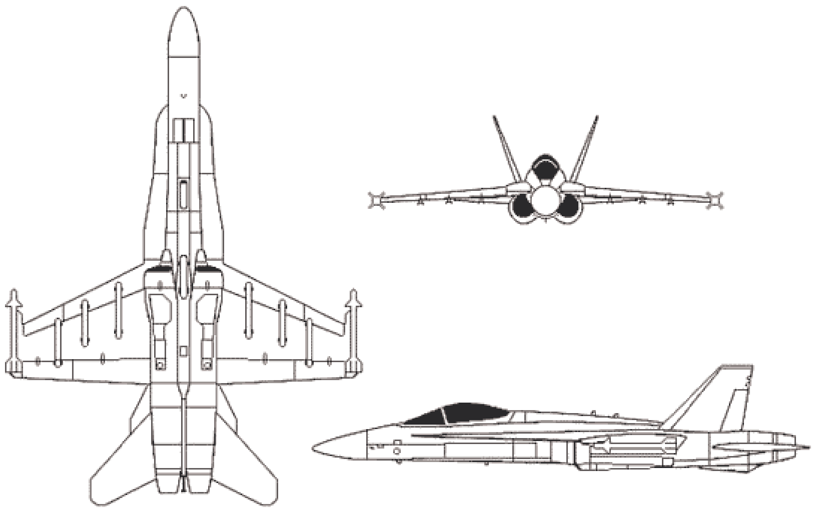
Crew: 4
Length: 46.61 m
Height: 12.93 m
Wing span: 44.4 m
Wing area: 283 sq m
Weight empty: 60000 kg
Normal weight: 100000 kg
Maximum weight: 148000 kg
Maximum fuel: 65000 kg
Service ceiling: 12000 m
Take-off speed: 208.8 km/h
Landing speed: 219.6 km/h
Maximum Mach at S/L: 0.82
Maximum Mach at height: 0.82
G limit: 2.5
Range with nominal load: 12247 km
Maximum range: 12247 km



# F/A-18C "Hornet"

***Type: Fighter/Attack Aircraft***

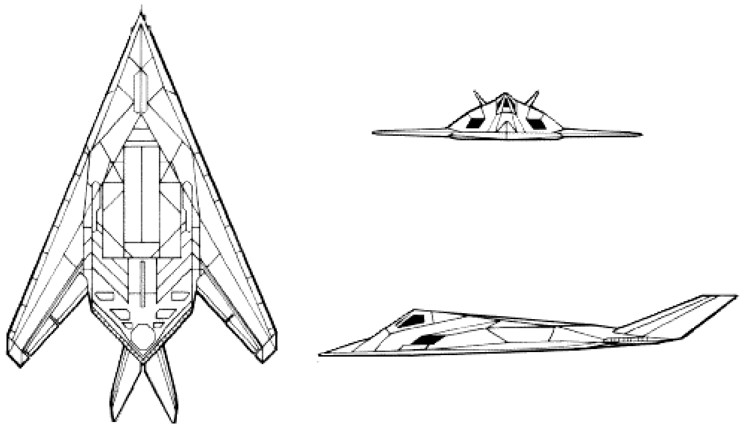
Crew: 1
Length: 17.07 m
Height: 4.66 m
Wing span: 11.43 m
Wing area: 37 sq m
Weight empty: 10810 kg
Normal weight: 16651 kg
Maximum weight: 25401 kg
Maximum fuel: 6531 kg
Service ceiling: 15240 m
Take-off speed: 248.4 km/h
Landing speed: 234 km/h
Maximum Mach at S/L: 1.1
Maximum Mach at height: 1.8
G limit: 7
Range with nominal load: 1520 km
Maximum range: 1520 km



# F-117A "Nighthawk"

**Type: Attack/Light Bomber**

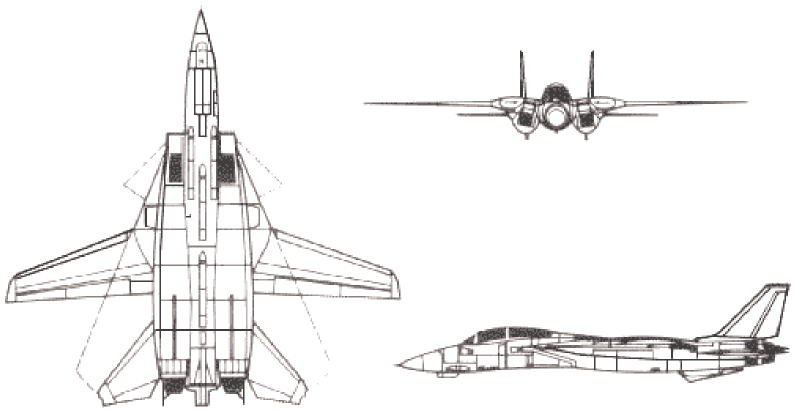
Crew: 1
Length: 20.08 m
Height: 3.78 m
Wing span: 13.2 m
Wing area: 105.9 sq m
Weight empty: 13380 kg
Normal weight: 18000 kg
Maximum weight: 23810 kg
Maximum fuel: 3840 kg
Service ceiling: 10000 m
Take-off speed: 306 km/h
Landing speed: 244.8 km/h
Maximum Mach at S/L: 1.08
Maximum Mach at height: 1.08
G limit: 4.5
Range with nominal load: 2000 km
Maximum range: 2000 km



# F-14A "Tomcat"

**Type: Multi-Role Fighter**

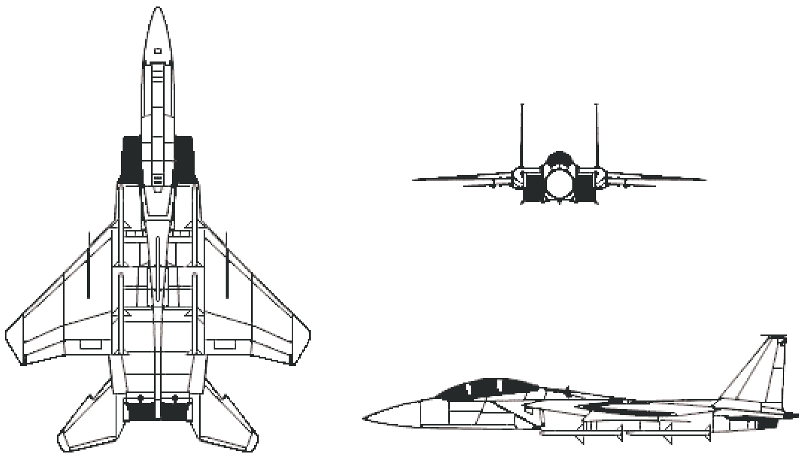
Crew: 2
Length: 19.1 m
Height: 4.88 m
Wing span: 19.54 m
Wing area: 52.5 sq m
Weight empty: 18951 kg
Normal weight: 29072 kg
Maximum weight: 33724 kg
Maximum fuel: 7348 kg
Service ceiling: 16150 m
Take-off speed: 185.04 km/h
Landing speed: 234 km/h
Maximum Mach at S/L: 1.2
Maximum Mach at height: 2.34
G limit: 6.5
Range with nominal load: 3200 km
Maximum range: 3200 km



# F-15C "Eagle"

***Type: Air-Superiority Fighter***

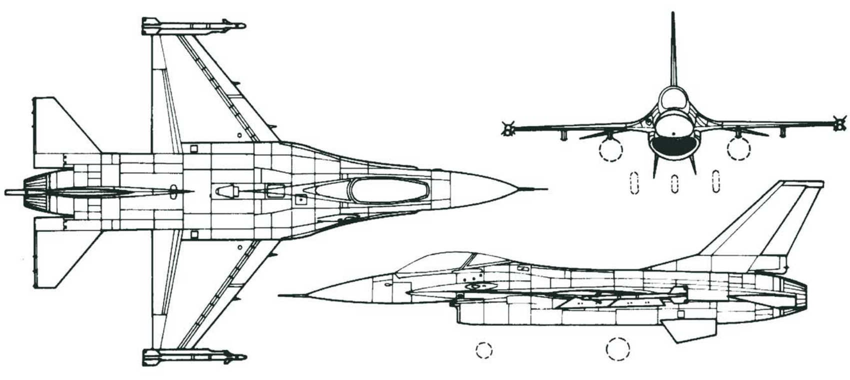
Crew: 1
Length: 19.43 m
Height: 5.63 m
Wing span: 13.05 m
Wing area: 56.5 sq m
Weight empty: 12790 kg
Normal weight: 19000 kg
Maximum weight: 30845 kg
Maximum fuel: 6103 kg
Service ceiling: 18300 m
Take-off speed: 219.6 km/h
Landing speed: 234 km/h
Maximum Mach at S/L: 1.2
Maximum Mach at height: 2.5
G limit: 8
Range with nominal load:
2540 km
Maximum range: 2540 km



# F-16C "Fighting Falcon"

***Type: Tactical Fighter***

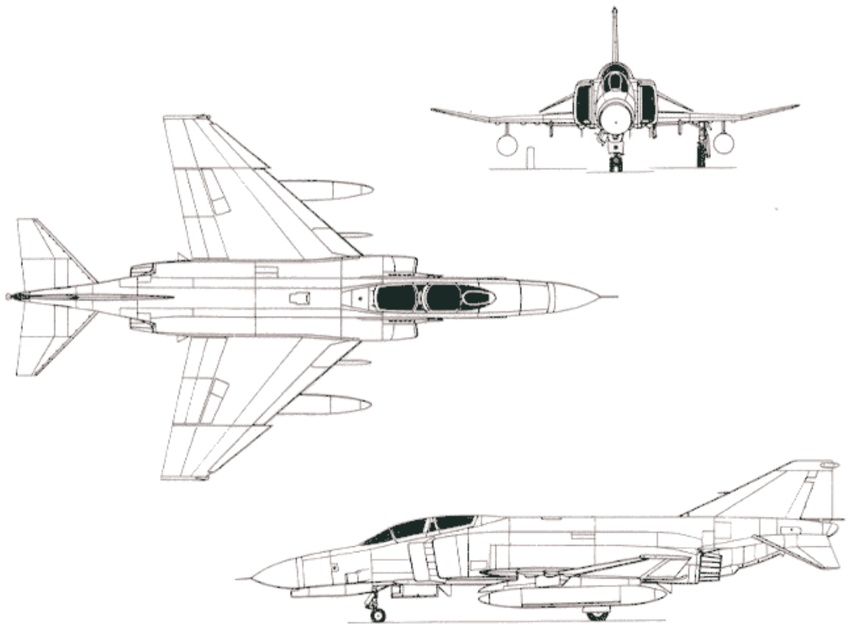
Crew: 1
Length: 14.52 m
Height: 5.02 m
Wing span: 9.45 m
Wing area: 28 sq m
Weight empty: 8853 kg
Normal weight: 11000 kg
Maximum weight: 19187 kg
Maximum fuel: 3104 kg
Service ceiling: 15240 m
Take-off speed: 234 km/h
Landing speed: 244.8 km/h
Maximum Mach at S/L: 1.1
Maximum Mach at height: 2
G limit: 8
Range with nominal load:
1500 km
Maximum range: 1500 km



# F-4E "Phantom II"

***Type: Multi-Role Fighter***

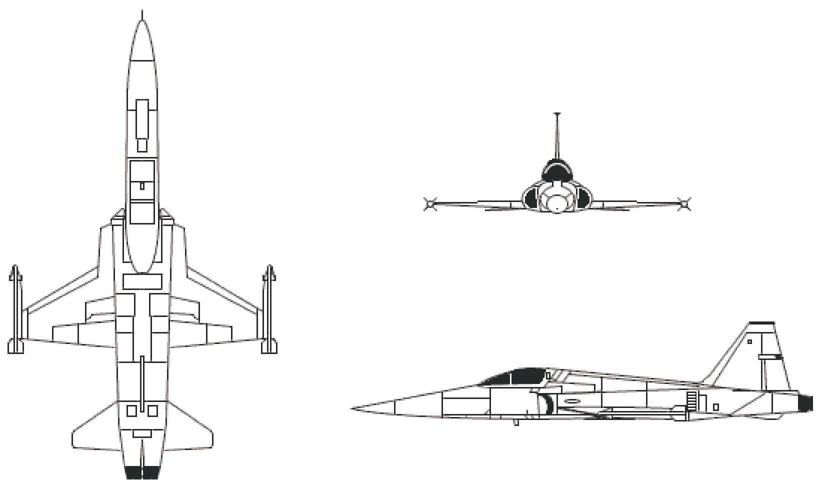
Crew: 2
Length: 19.2 m
Height: 5 m
Wing span: 11.68 m
Wing area: 49.24 sq m
Weight empty: 14461 kg
Normal weight: 24430 kg
Maximum weight: 28055 kg
Maximum fuel: 4864 kg
Service ceiling: 17907 m
Take-off speed: 208.8 km/h
Landing speed: 219.6 km/h
Maximum Mach at S/L: 1.09
Maximum Mach at height: 2.17
G limit: 5.9
Range with nominal load: 2593 km
Maximum range: 2593 km



# F-5E "Tiger"

***Type: Tactical Fighter***

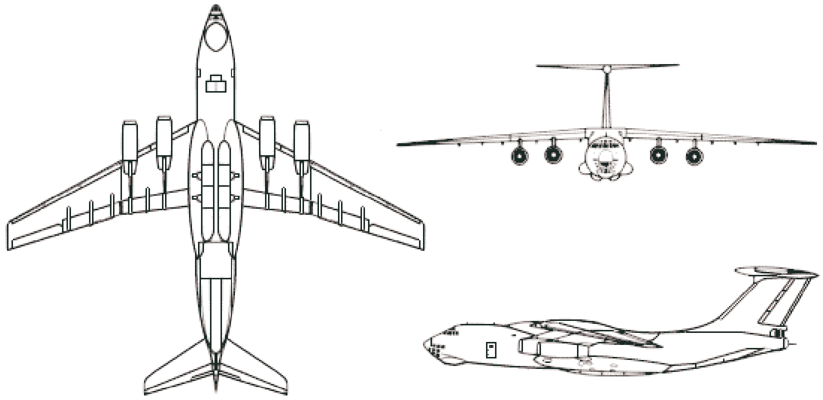
Crew: 1
Length: 14.68 m
Height: 4.06 m
Wing span: 8.53 m
Wing area: 17.3 sq m
Weight empty: 4392 kg
Normal weight: 7800 kg
Maximum weight: 11187 kg
Maximum fuel: 2000 kg
Service ceiling: 11000 m
Take-off speed: 234 km/h
Landing speed: 244.8 km/h
Maximum Mach at S/L: 1.1
Maximum Mach at height: 1.61
G limit: 7.5
Range with nominal load: 2112 km
Maximum range: 2112 km



# IL-76MD "Candid-B"

**Type: Long-Range Transport**

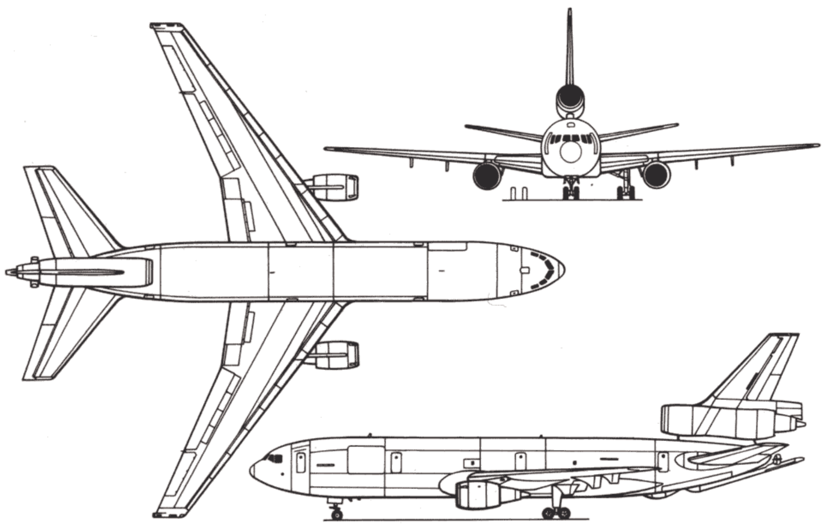
Crew: 4
Length: 46.59 m
Height: 14.76 m
Wing span: 50.5 m
Wing area: 300 sq m
Weight empty: 100000 kg
Normal weight: 150000 kg
Maximum weight: 180000 kg
Maximum fuel: 80000 kg
Service ceiling: 12000 m
Take-off speed: 208.8 km/h
Landing speed: 219.6 km/h
Maximum Mach at S/L: 0.77
Maximum Mach at height: 0.77
G limit: 2.5
Range with nominal load: 7300 km
Maximum range: 7300 km



# KC-10A "Extender"

**Type: Flight Refuelling Tanker**

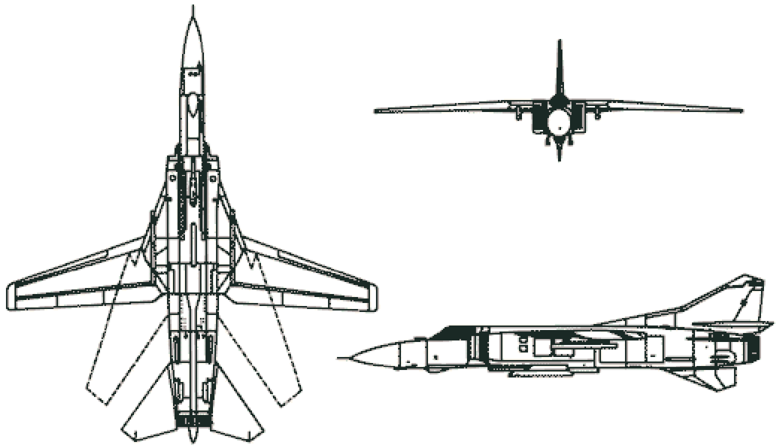
Crew: 4
Length: 55.35 m
Height: 17.7 m
Wing span: 50.4 m
Wing area: 367.7 sq m
Weight empty: 110664 kg
Normal weight: 150000 kg
Maximum weight: 267000 kg
Maximum fuel: 80000 kg
Service ceiling: 12000 m
Take-off speed: 208.8 km/h
Landing speed: 219.6 km/h
Maximum Mach at S/L: 0.77
Maximum Mach at height: 0.77
G limit: 2.5
Range with nominal load: 7800 km
Maximum range: 7800 km



# MiG-23MLD "Flogger-E"

***Type: Fighter***

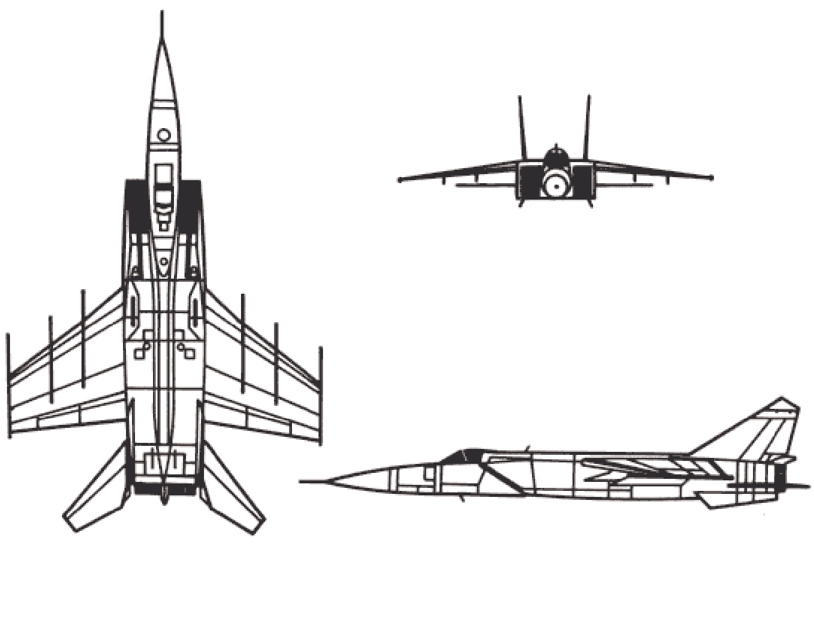
Crew: 1
Length: 15.7 m
Height: 5.772 m
Wing span: 14 m
Wing area: 37 sq m
Weight empty: 10550 kg
Normal weight: 14700 kg
Maximum weight: 17800 kg
Maximum fuel: 3800 kg
Service ceiling: 18500 m
Take-off speed: 252 km/h
Landing speed: 252 km/h
Maximum Mach at S/L: 1.1
Maximum Mach at height: 2.35
G limit: 6.5
Range with nominal load: 1950 km
Maximum range: 1950 km



# MiG-25PD "Foxbat-A"

***Type: Interceptor***

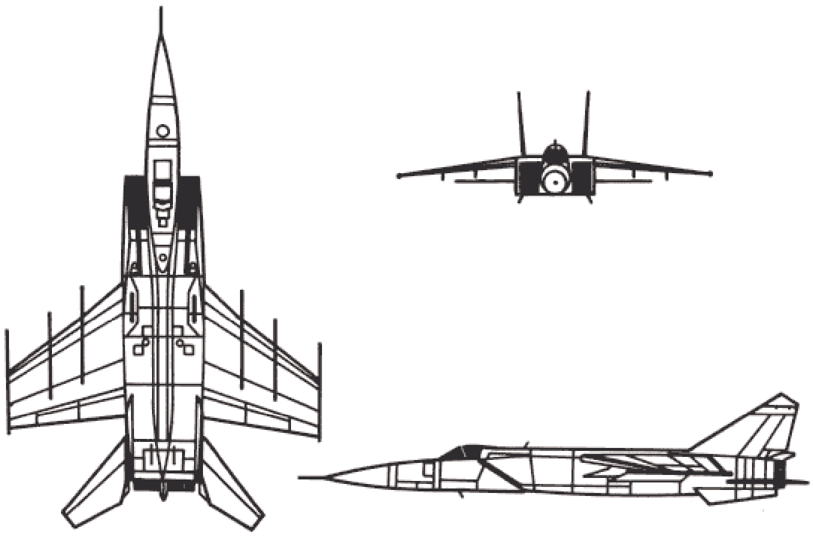
Crew: 1
Length: 23.82 m
Height: 6.1 m
Wing span: 14 m
Wing area: 61 sq m
Weight empty: 20000 kg
Normal weight: 37500 kg
Maximum weight: 41200 kg
Maximum fuel: 15245 kg
Service ceiling: 24200 m
Take-off speed: 270 km/h
Landing speed: 270 km/h
Maximum Mach at S/L: 1.2
Maximum Mach at height: 2.83
G limit: 4.5
Range with nominal load: 1250 km
Maximum range: 1920 km



# MiG-25RBT "Foxbat-B"

**Type: Reconnaissance**

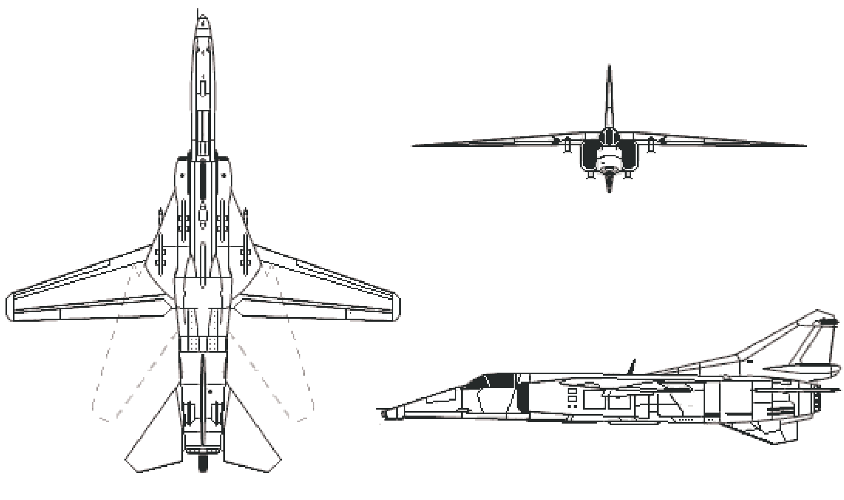
Crew: 1
Length: 23.82 m
Height: 6.1 m
Wing span: 14 m
Wing area: 61 sq m
Weight empty: 20000 kg
Normal weight: 37500 kg
Maximum weight: 41200 kg
Maximum fuel: 15245 kg
Service ceiling: 24200 m
Take-off speed: 270 km/h
Landing speed: 270 km/h
Maximum Mach at S/L: 1.2
Maximum Mach at height: 2.83
G limit: 4.5
Range with nominal load: 1250 km
Maximum range: 1920 km



# MiG-27K "Flogger-D"

**Type: Tactical Attack Fighter**

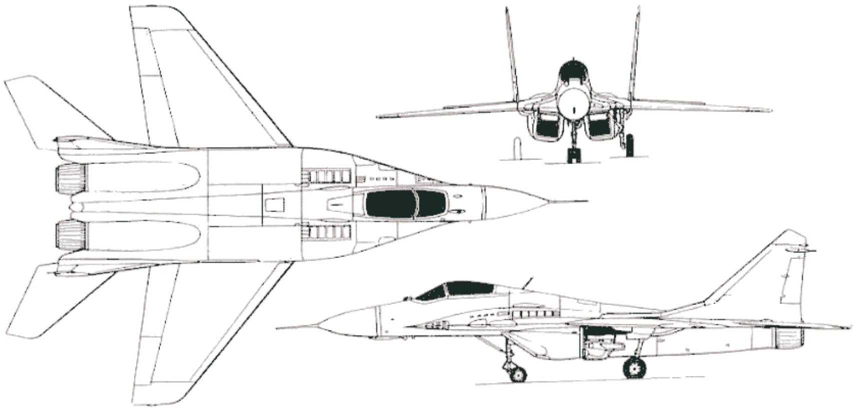
Crew: 1
Length: 16.7 m
Height: 5.64 m
Wing span: 14 m
Wing area: 34 sq m
Weight empty: 11000 kg
Normal weight: 15200 kg
Maximum weight: 18900 kg
Maximum fuel: 4500 kg
Service ceiling: 17000 m
Take-off speed: 302.4 km/h
Landing speed: 288 km/h
Maximum Mach at S/L: 1.2
Maximum Mach at height: 1.7
G limit: 5.9
Range with nominal load: 1950 km
Maximum range: 1950 km



## MiG-29A "Fulcrum-A"

***Type: Counter-Air Fighter***

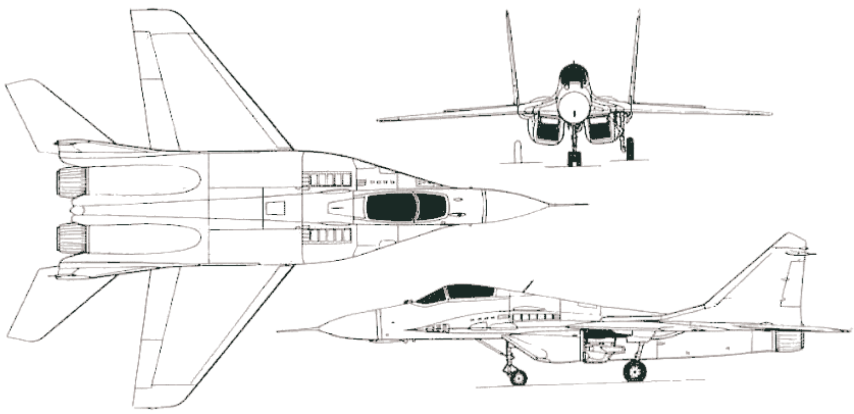
Crew: 1
Length: 17.32 m
Height: 4.73 m
Wing span: 11.36 m
Wing area: 38.1 sq m
Weight empty: 11200 kg
Normal weight: 13240 kg
Maximum weight: 19700 kg
Maximum fuel: 4540 kg
Service ceiling: 18000 m
Take-off speed: 241.2 km/h
Landing speed: 252 km/h
Maximum Mach at S/L: 1.225
Maximum Mach at height: 2.3
G limit: 8
Range with nominal load: 1500 km
Maximum range: 1500 km



## MIG-29S "Fulcrum-C"

***Type: Counter-Air Fighter***

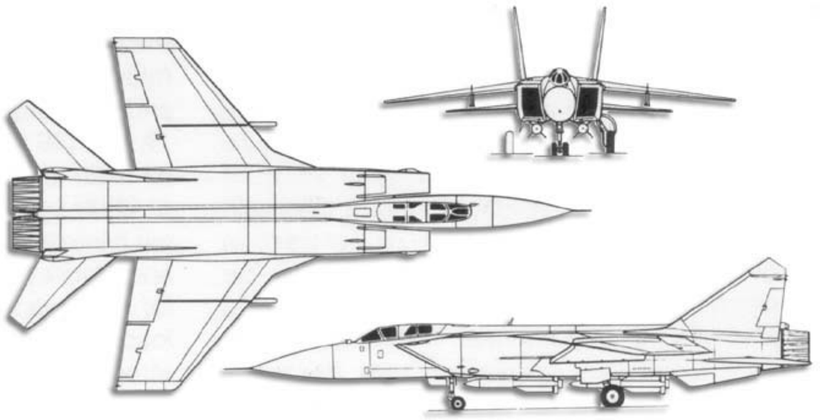
Crew: 1
Length: 17.32 m
Height: 4.73 m
Wing span: 11.36 m
Wing area: 38.1 sq m
Weight empty: 11200 kg
Normal weight: 13240 kg
Maximum weight: 19700 kg
Maximum fuel: 4540 kg
Service ceiling: 18000 m
Take-off speed: 241.2 km/h
Landing speed: 252 km/h
Maximum Mach at S/L: 1.225
Maximum Mach at height: 2.3
G limit: 8
Range with nominal load: 1500 km
Maximum range: 1500 km



# MiG-31 "Foxhound"

**Type: Strategic Interceptor**

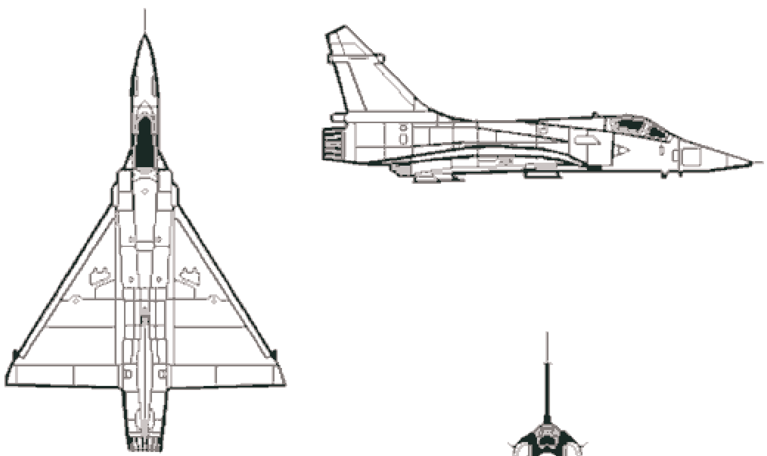
Crew: 2
Length: 22.7 m
Height: 6.15 m
Wing span: 13.46 m
Wing area: 61.6 sq m
Weight empty: 21820 kg
Normal weight: 35000 kg
Maximum weight: 46200 kg
Maximum fuel: 15500 kg
Service ceiling: 21000 m
Take-off speed: 259.2 km/h
Landing speed: 259.2 km/h
Maximum Mach at S/L: 1.225
Maximum Mach at height: 2.83
G limit: 5
Range with nominal load: 2400 km
Maximum range: 2400 km



# Mirage 2000-5

**Type: Multi-Role Fighter**

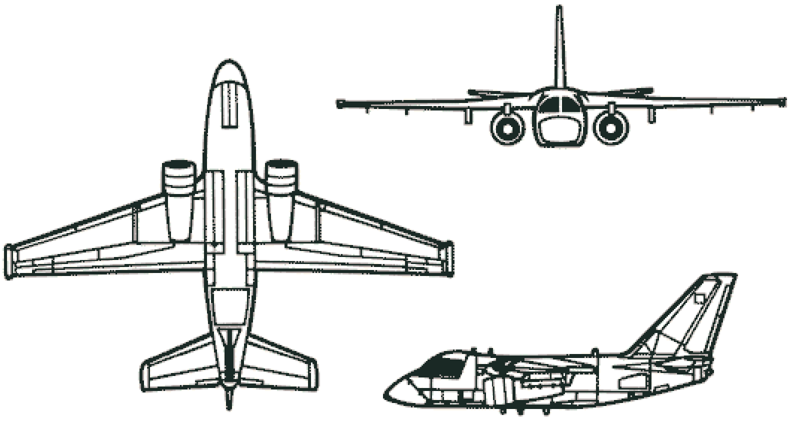
Crew: 1
Length: 14.36 m
Height: 5.2 m
Wing span: 9.13 m
Wing area: 41 sq m
Weight empty: 7500 kg
Normal weight: 9525 kg
Maximum weight: 17000 kg
Maximum fuel: 3160 kg
Service ceiling: 16460 m
Take-off speed: 230.4 km/h
Landing speed: 230.4 km/h
Maximum Mach at S/L: 1.2
Maximum Mach at height: 2.2
G limit: 9
Range with nominal load: 1852 km
Maximum range: 1852 km



## S-3B "Viking"

*Type: Carrier Based Patrol/Attack*

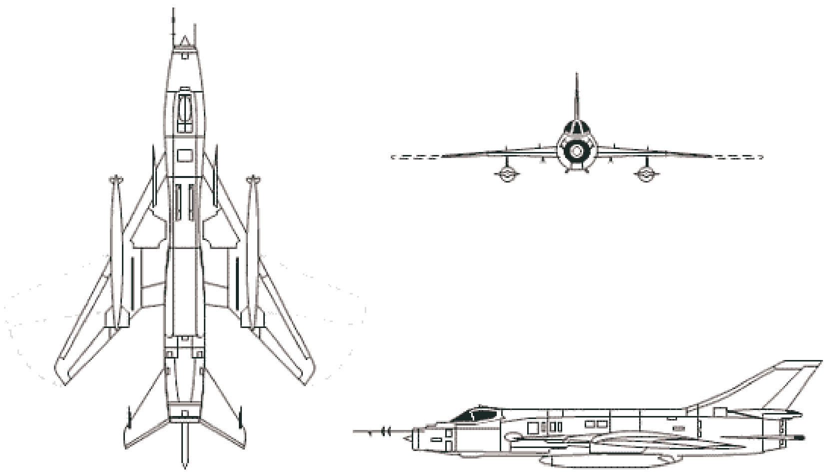
Crew: 4
Length: 16.26 m
Height: 6.93 m
Wing span: 20.93 m
Wing area: 55.55 sq m
Weight empty: 12088 kg
Normal weight: 19278 kg
Maximum weight: 23831 kg
Maximum fuel: 5500 kg
Service ceiling: 7500 m
Take-off speed: 216 km/h
Landing speed: 190.08 km/h
Maximum Mach at S/L: 0.682
Maximum Mach at height: 0.682
G limit: 2.5
Range with nominal load: 3701 km
Maximum range: 3701 km



## Su-17M4 "Fitter-D"

*Type: Close Support Aircraft*

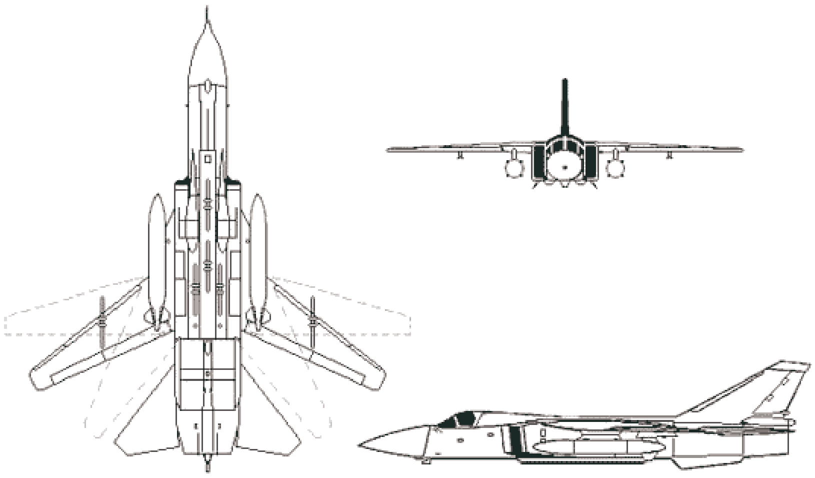
Crew: 1
Length: 19.26 m
Height: 5.129 m
Wing span: 13.68 m
Wing area: 38.5 sq m
Weight empty: 10670 kg
Normal weight: 15230 kg
Maximum weight: 19430 kg
Maximum fuel: 3770 kg
Service ceiling: 15200 m
Take-off speed: 360 km/h
Landing speed: 284.4 km/h
Maximum Mach at S/L: 1.1
Maximum Mach at height: 1.7
G limit: 5.9
Range with nominal load: 1760 km
Maximum range: 2300 km



## Su-24 "Fencer"

***Type: Battlefield Bomber***

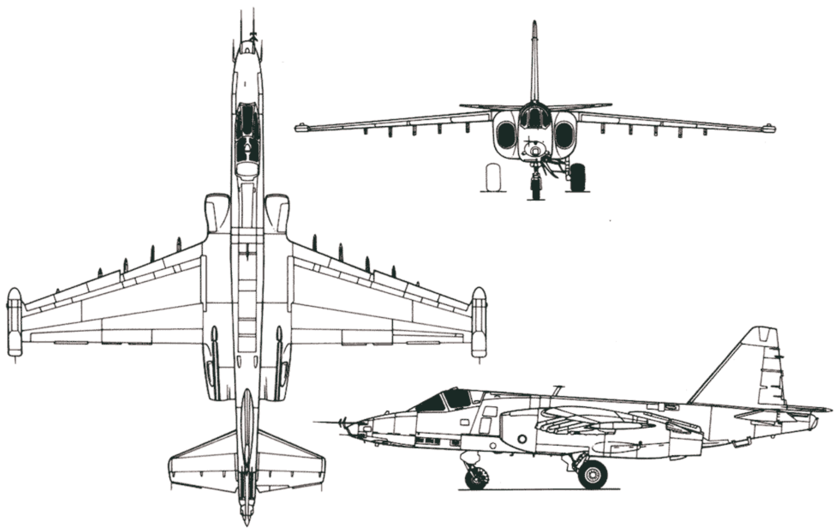
Crew: 2
Length: 24.53 m
Height: 4.97 m
Wing span: 17.64 m
Wing area: 55.17 sq m
Weight empty: 22300 kg
Normal weight: 33325 kg
Maximum weight: 39700 kg
Maximum fuel: 11700 kg
Service ceiling: 17500 m
Take-off speed: 280.8 km/h
Landing speed: 270 km/h
Maximum Mach at S/L: 1.08
Maximum Mach at height: 1.35
G limit: 5.9
Range with nominal load: 1200 km
Maximum range: 1200 km



## Su-25 "Frogfoot"

***Type: Close Support Aircraft***

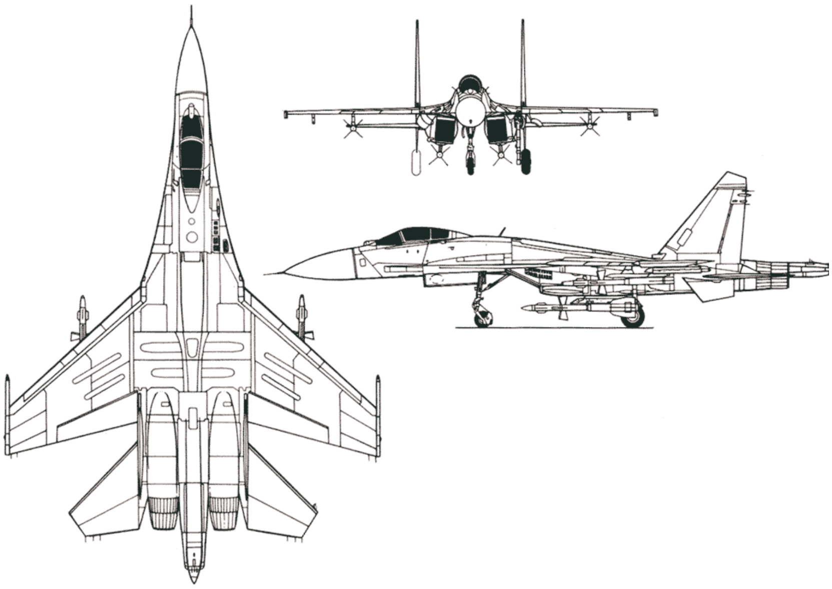
Crew: 1
Length: 15.36 m
Height: 4.8 m
Wing span: 14.35 m
Wing area: 30.1 sq m
Weight empty: 9500 kg
Normal weight: 12750 kg
Maximum weight: 17600 kg
Maximum fuel: 3000 kg
Service ceiling: 7000 m
Take-off speed: 259.2 km/h
Landing speed: 244.8 km/h
Maximum Mach at S/L: 0.77
Maximum Mach at height: 0.8
G limit: 5.9
Range with nominal load: 1250 km
Maximum range: 1250 km



# Su-27 "Flanker-B"

***Type: Air-superiority Fighter***

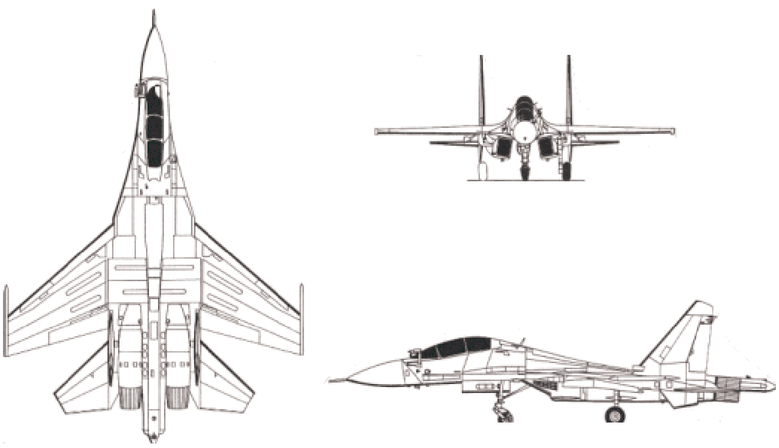
Crew: 1
Length: 22 m
Height: 5.93 m
Wing span: 14.7 m
Wing area: 65 sq m
Weight empty: 16000 kg
Normal weight: 20000 kg
Maximum weight: 30000 kg
Maximum fuel: 9400 kg
Service ceiling: 18500 m
Take-off speed: 270 km/h
Landing speed: 234 km/h
Maximum Mach at S/L: 1.14
Maximum Mach at height: 2.35
G limit: 9
Range with nominal load: 3740 km
Maximum range: 3740 km



# Su-30 "Flanker-C"

***Type: Long-Range Interceptor***

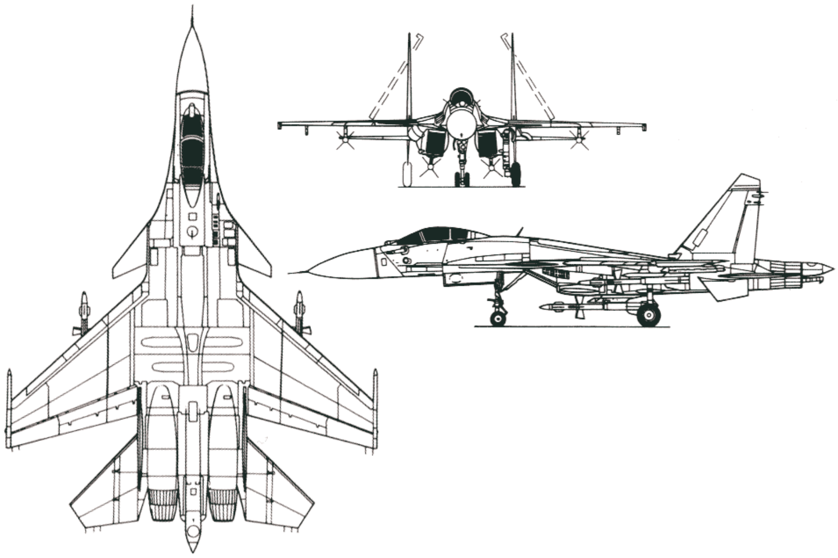
Crew: 2
Length: 22 m
Height: 6.35 m
Wing span: 14.7 m
Wing area: 62 sq m
Weight empty: 17700 kg
Normal weight: 22000 kg
Maximum weight: 30500 kg
Maximum fuel: 9400 kg
Service ceiling: 17250 m
Take-off speed: 270 km/h
Landing speed: 234 km/h
Maximum Mach at S/L: 1.14
Maximum Mach at height: 2.35
G limit: 9
Range with nominal load: 3000 km
Maximum range: 3000 km



# Su-33 "Flanker-D"

***Type: Ship-based Air Defence***

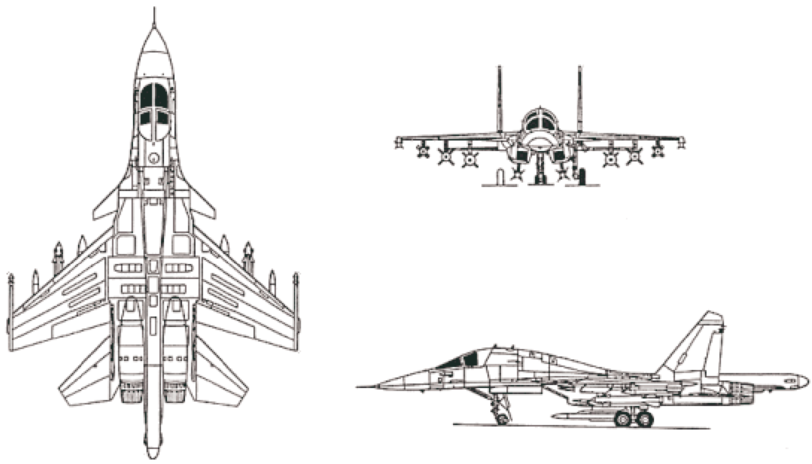
Crew: 1
Length: 21.2 m
Height: 5.9 m
Wing span: 14.7 m
Wing area: 65 sq m
Weight empty: 18500 kg
Normal weight: 20000 kg
Maximum weight: 33000 kg
Maximum fuel: 8500 kg
Service ceiling: 18500 m
Take-off speed: 270 km/h
Landing speed: 234 km/h
Maximum Mach at S/L: 1.14
Maximum Mach at height: 2.165
G limit: 9
Range with nominal load: 3000 km
Maximum range: 3000 km



# Su-34 "Platypus"

***Type: Long-Range Theatre Bomber***

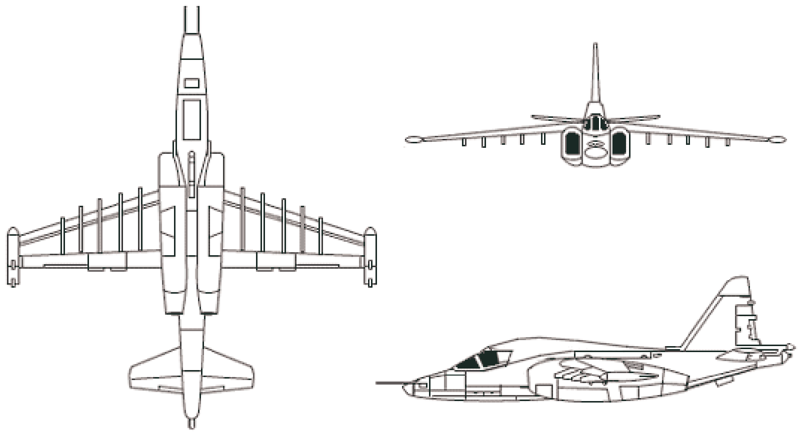
Crew: 2
Length: 23.3 m
Height: 6 m
Wing span: 14.7 m
Wing area: 62 sq m
Weight empty: 22300 kg
Normal weight: 33325 kg
Maximum weight: 45000 kg
Maximum fuel: 9800 kg
Service ceiling: 15000 m
Take-off speed: 270 km/h
Landing speed: 234 km/h
Maximum Mach at S/L: 1.14
Maximum Mach at height: 1.8
G limit: 7
Range with nominal load: 4000 km
Maximum range: 4000 km



# *Su-39 "Frogfoot"*

***Type: Close Support Aircraft***

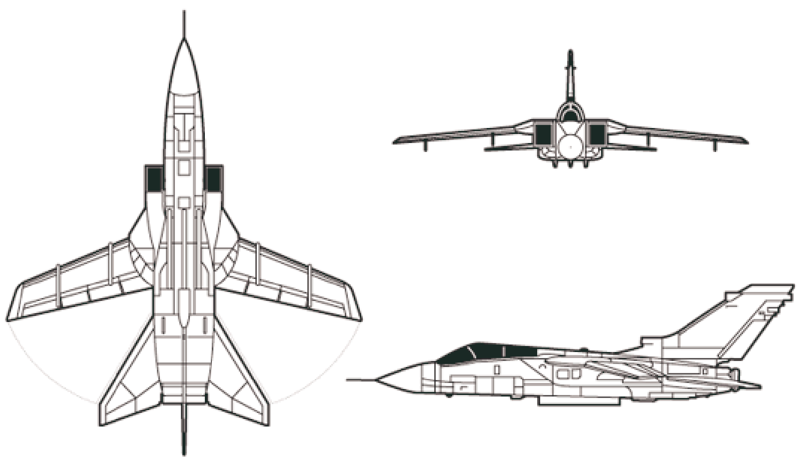
Crew: 1
Length: 15.35 m
Height: 5.2 m
Wing span: 14.36 m
Wing area: 30.1 sq m
Weight empty: 10600 kg
Normal weight: 12750 kg
Maximum weight: 19500 kg
Maximum fuel: 3840 kg
Service ceiling: 10000 m
Take-off speed: 259.2 km/h
Landing speed: 244.8 km/h
Maximum Mach at S/L: 0.77
Maximum Mach at height: 0.82
G limit: 5.9
Range with nominal load: 2250 km
Maximum range: 2250 km



# *Tornado F.2 IDS GR.1A*

***Type: Multi-Role Combat***

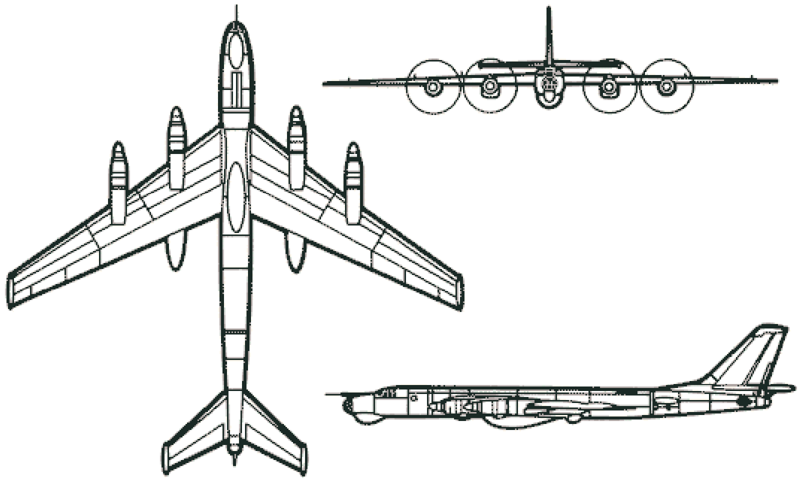
Crew: 2
Length: 16.7 m
Height: 5.7 m
Wing span: 13.91 m
Wing area: 26.6 sq m
Weight empty: 14090 kg
Normal weight: 20000 kg
Maximum weight: 26490 kg
Maximum fuel: 4663 kg
Service ceiling: 15200 m
Take-off speed: 212.4 km/h
Landing speed: 212.4 km/h
Maximum Mach at S/L: 1.2
Maximum Mach at height: 2.2
G limit: 7.5
Range with nominal load: 2780 km
Maximum range: 2780 km



# Tu-142 "Bear-M"

***Type: Anti-Submarine Warfare***

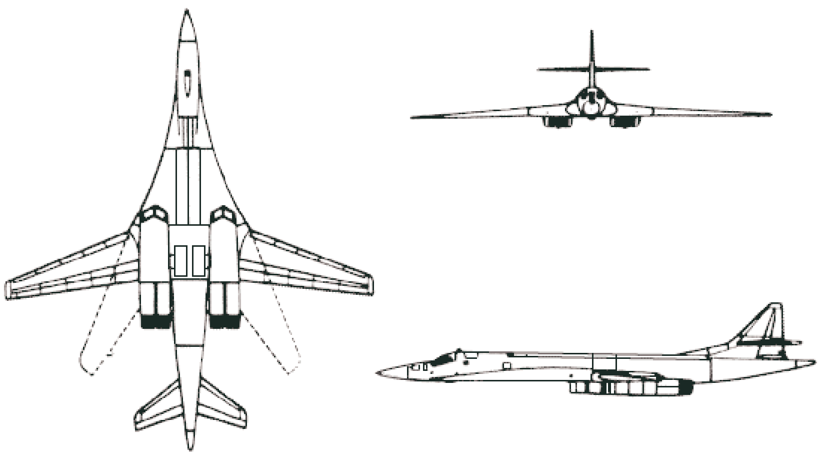
Crew: 10
Length: 49.13 m
Height: 13.3 m
Wing span: 50.04 m
Wing area: 295 sq m
Weight empty: 96000 kg
Normal weight: 150000 kg
Maximum weight: 185000 kg
Maximum fuel: 87000 kg
Service ceiling: 12000 m
Take-off speed: 288 km/h
Landing speed: 270 km/h
Maximum Mach at S/L: 0.53
Maximum Mach at height: 0.83
G limit: 2.5
Range with nominal load: 6400 km
Maximum range: 6400 km



# Tu-160 "Blackjack"

***Type: Long-Range Bomber***

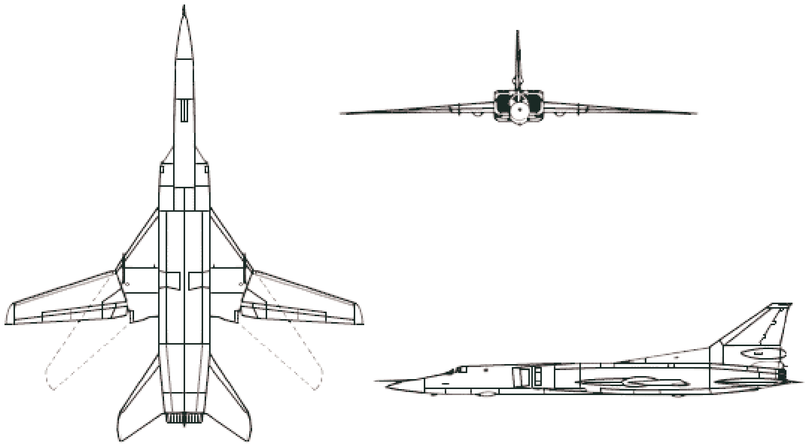
Crew: 4
Length: 54.1 m
Height: 13.25 m
Wing span: 55.7 m
Wing area: 360 sq m
Weight empty: 117000 kg
Normal weight: 200000 kg
Maximum weight: 275000 kg
Maximum fuel: 157000 kg
Service ceiling: 15000 m
Take-off speed: 284.4 km/h
Landing speed: 280.8 km/h
Maximum Mach at S/L: 1.06
Maximum Mach at height: 2.05
G limit: 3.5
Range with nominal load: 12300 km
Maximum range: 12300 km



## Tu-22M3 "Backfire-C"

**Type: Medium Bomber**

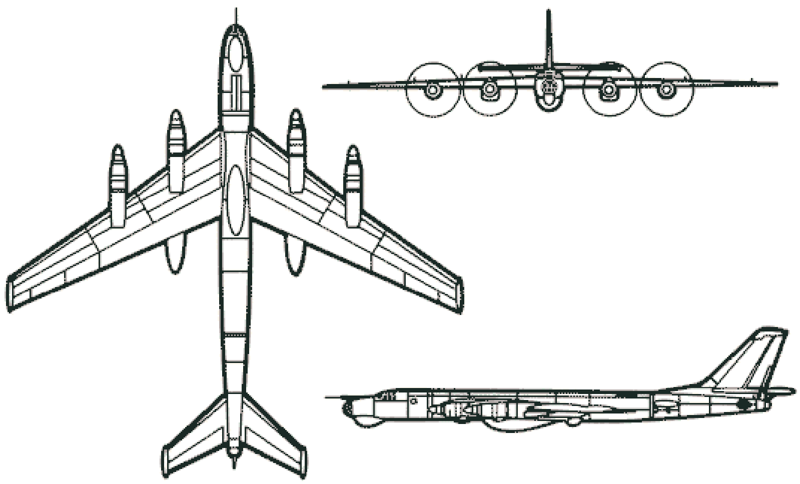
Crew: 4
Length: 46.12 m
Height: 11.05 m
Wing span: 34.28 m
Wing area: 183 sq m
Weight empty: 50000 kg
Normal weight: 88000 kg
Maximum weight: 124000 kg
Maximum fuel: 50000 kg
Service ceiling: 13500 m
Take-off speed: 284.4 km/h
Landing speed: 280.8 km/h
Maximum Mach at S/L: 0.86
Maximum Mach at height: 1.88
G limit: 3.5
Range with nominal load: 2410 km
Maximum range: 2410 km



## Tu-95 "Bear"

**Type: Long-Range Bomber**

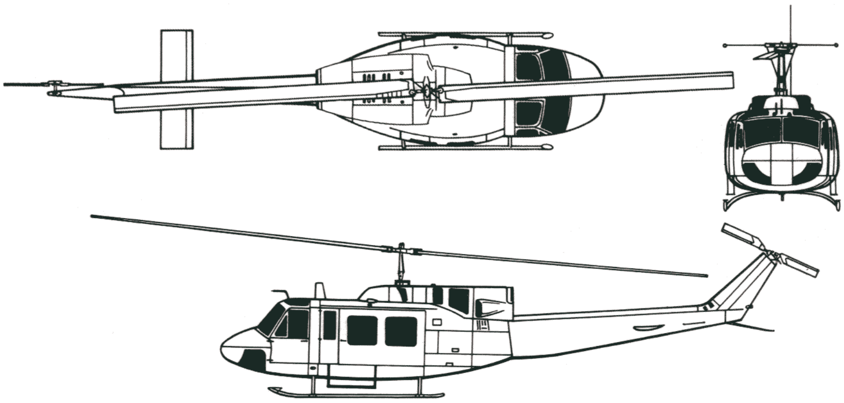
Crew: 10
Length: 49.13 m
Height: 13.3 m
Wing span: 50.04 m
Wing area: 295 sq m
Weight empty: 96000 kg
Normal weight: 150000 kg
Maximum weight: 185000 kg
Maximum fuel: 87000 kg
Service ceiling: 12000 m
Take-off speed: 288 km/h
Landing speed: 270 km/h
Maximum Mach at S/L: 0.53
Maximum Mach at height: 0.83
G limit: 2.5
Range with nominal load: 6400 km
Maximum range: 6400 km



## AB-212ASW

**Type: Anti-Submarine**

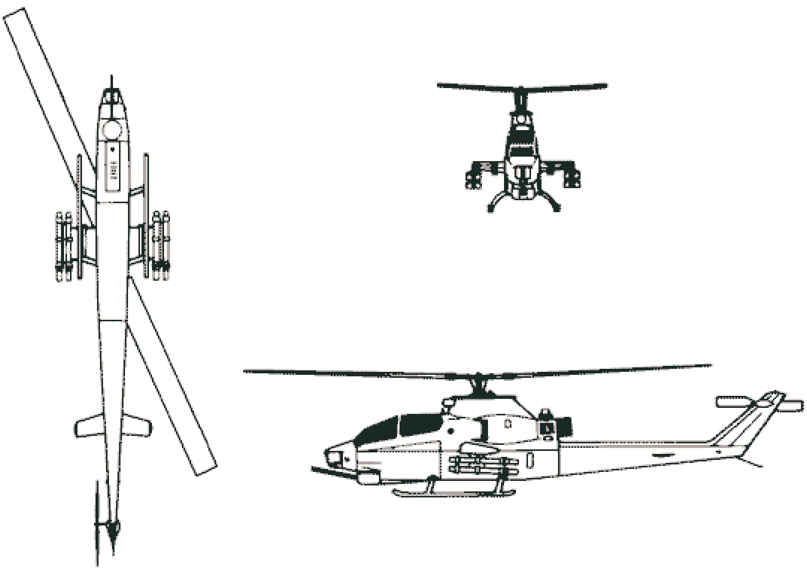
Crew: 2
Length: 17.62 m
Height: 4.41 m
Propeller diameter: 14.63 m
Weight empty: 2520 kg
Normal weight: 3415 kg
Maximum weight: 4310 kg
Maximum fuel: 680 kg
Service celling: 2,150 m
Maximum speed: 240 km/h
Maximum range: 510 km



## AH-1W "SuperCobra"

**Type: Close Support/Attack**

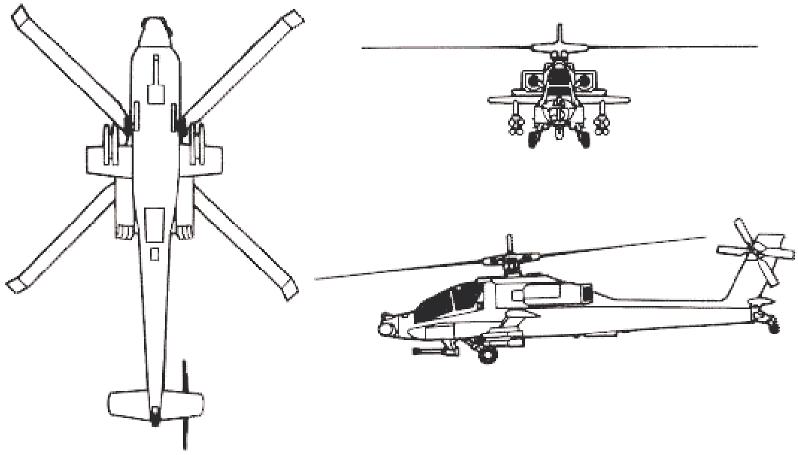
Crew: 2
Length: 17.27 m
Height: 3.9 m
Propeller diameter: 15 m
Weight empty: 4634 kg
Normal weight: 6352 kg
Maximum weight: 6690 kg
Maximum fuel: 946.4 kg
Service celling: 1,470 m
Maximum speed: 352 km/h
Maximum range: 595 km



# AH-64A "Apache"

***Type: Attack***

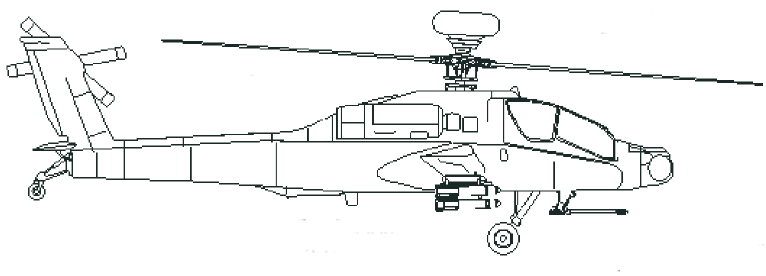
Crew: 2
Length: 17.87 m
Height: 4.15 m
Propeller diameter: 14.72 m
Weight empty: 4881 kg
Normal weight: 6552 kg
Maximum weight: 9225 kg
Maximum fuel: 1157 kg
Service celling: 4570 m
Maximum speed: 365 km/h
Range with nominal load: 480 km
Maximum range: 480 km



# AH-64D "Longbow Apache"

***Type: Attack***

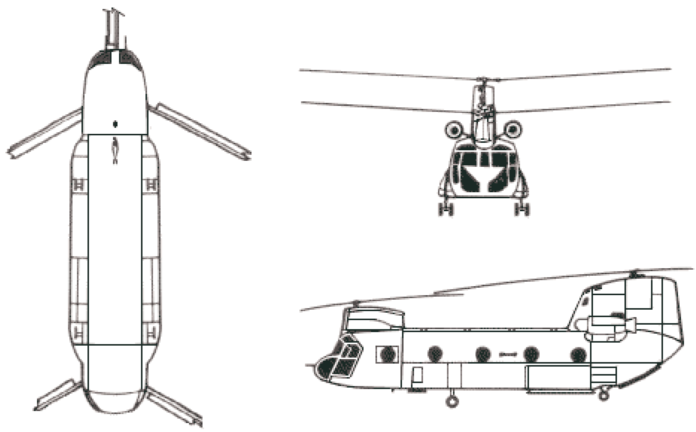
Crew: 2
Length: 17.87 m
Height: 5.087 m
Propeller diameter: 14.72 m
Weight empty: 4881 kg
Normal weight: 7480 kg
Maximum weight: 10107 kg
Maximum fuel: 1157 kg
Service celling: 4115 m
Maximum speed: 365 km/h
Maximum range: 407 km



# CH-47D "Chinook"

***Type: Transport***

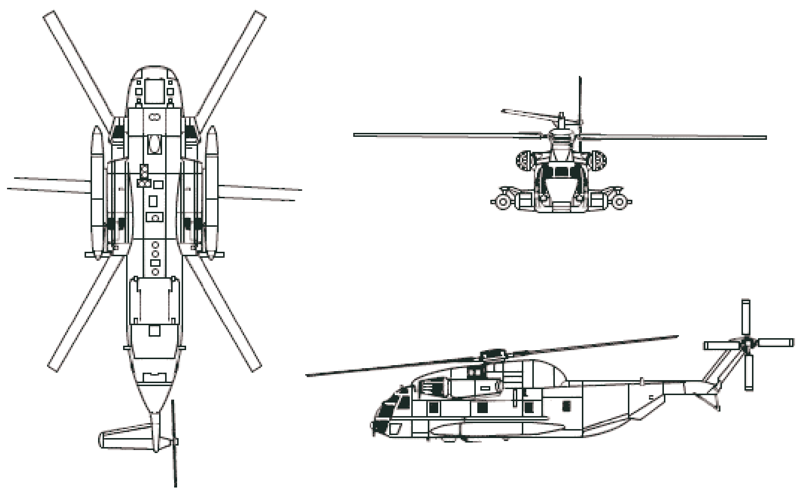
Crew: 2
Length: 28.3 m
Height: 5.998 m
Propeller diameter: 17.8 m
Weight empty: 10615 kg
Normal weight: 17460 kg
Maximum weight: 22680 kg
Maximum fuel: 3120 kg
Service celling: 2675 m
Maximum speed: 285 km/h
Maximum range: 615 km



# CH-53E "Super Stallion"

***Type: Heavy-lift***

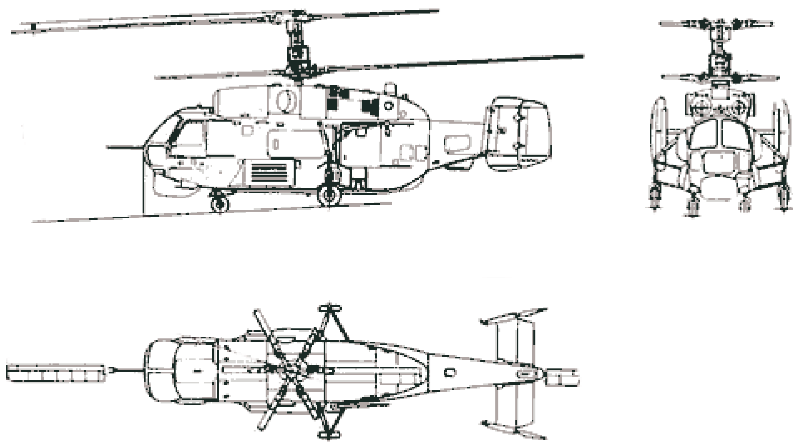
Crew: 3
Length: 30.18 m
Height: 7.83 m
Propeller diameter: 24.07 m
Weight empty: 16480 kg
Normal weight: 25400 kg
Maximum weight: 31630 kg
Maximum fuel: 1908 kg
Service celling: 3520 m
Maximum speed: 315 km/h
Range with nominal load: 536 km
Maximum range: 536 km



# Ka-27 "Helix"

***Type: Multipurpose***

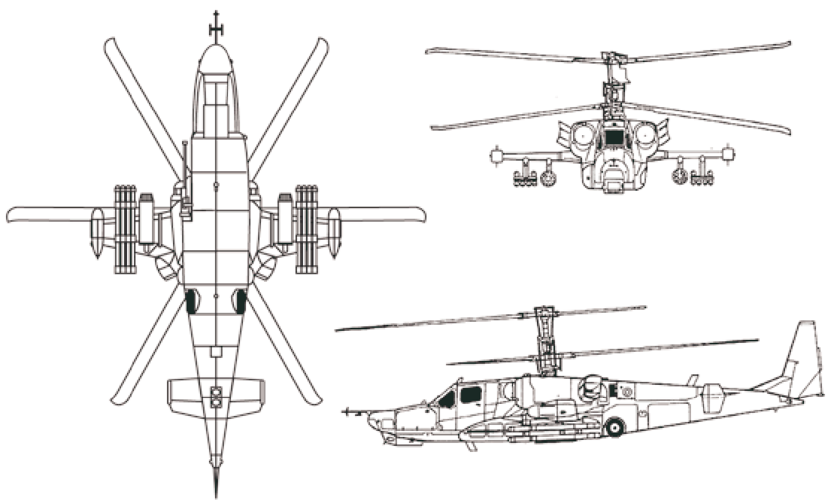
Crew: 3
Length: 15.92 m
Height: 5.2 m
Propeller diameter: 15.9 m
Weight empty: 6800 kg
Normal weight: 11000 kg
Maximum weight: 13000 kg
Maximum fuel: 1450 kg
Service ceiling: 3000 m
Maximum speed: 270 km/h
Maximum range: 800 km



# Ka-50 "Hokum-A"

***Type: Close Support***

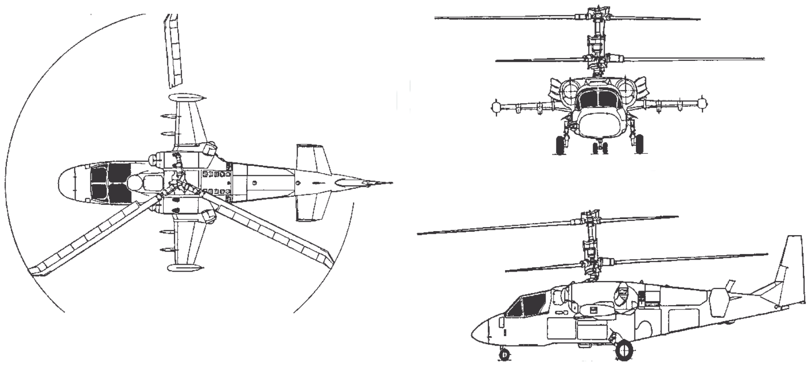
Crew: 1
Length: 15.84 m
Height: 5.6 m
Propeller diameter: 14.45 m
Weight empty: 7700 kg
Normal weight: 9800 kg
Maximum weight: 10800 kg
Maximum fuel: 2400 kg
Service celling: 5070 m
Maximum speed: 350 km/h
G limit: 3.5
Maximum range: 450 km



## Ka-52 "Hokum-B"

**Type: Close Support**

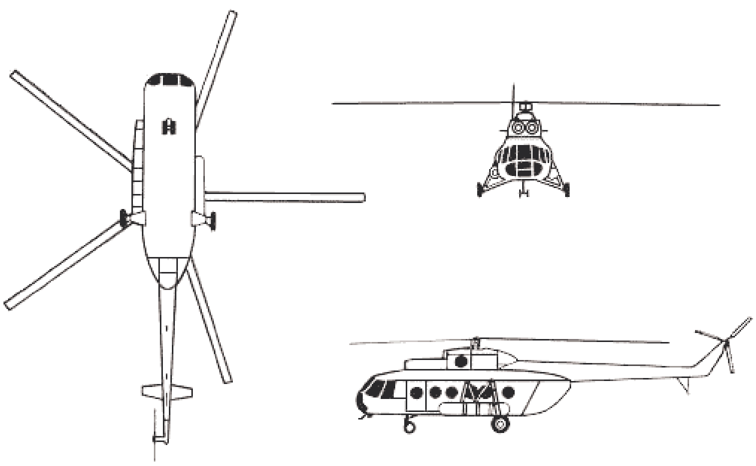
Crew: 2
Length: 15.84 m
Height: 5.6 m
Propeller diameter: 14.45 m
Weight empty: 7700 kg
Normal weight: 9800 kg
Maximum weight: 10800 kg
Maximum fuel: 2400 kg
Service ceiling: 5070 m
Maximum speed: 350 km/h
G limit: 3.5
Maximum range: 450 km
Armament: GSh-301



## Mi-8MT "Hip"

**Type: Medium Transport**

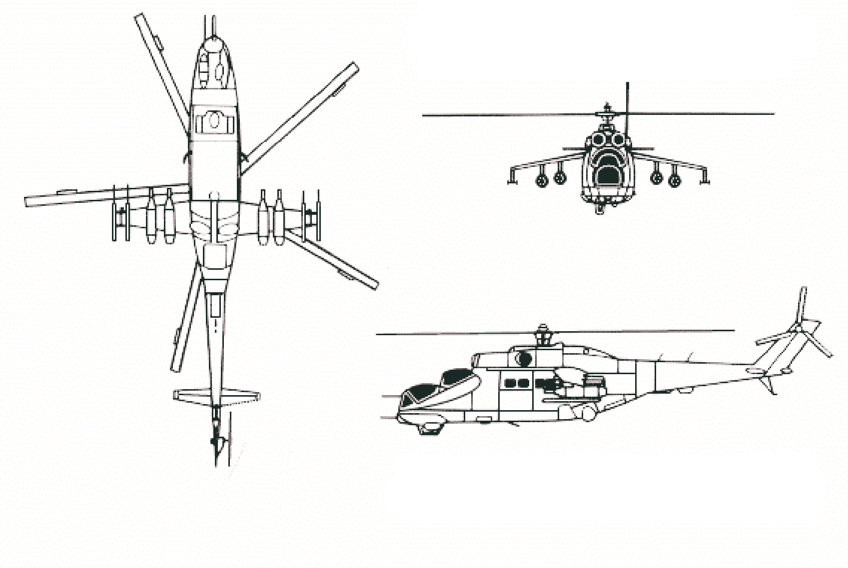
Crew: 2
Length: 25.942 m
Height: 4.908 m
Propeller diameter: 21.4 m
Weight empty: 6800 kg
Normal weight: 11100 kg
Maximum weight: 13000 kg
Maximum fuel: 2296 kg
Service ceiling: 1800 m
Maximum speed: 250 km/h
Maximum range: 580 km



# *Mi-24 "Hind"*

***Type: Gunship***

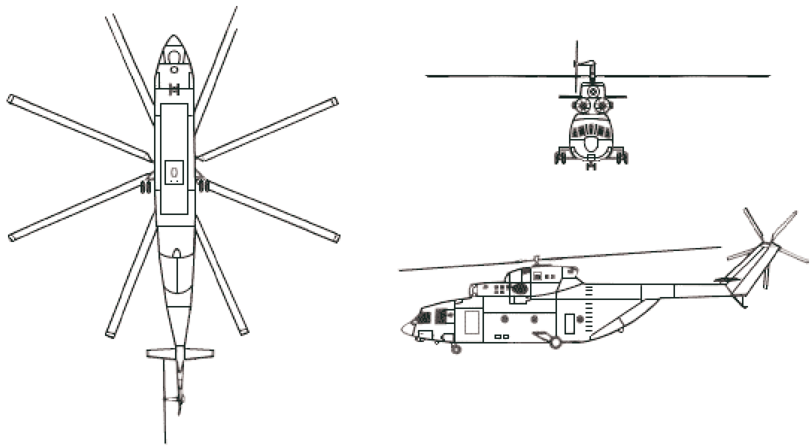
Crew: 2
Length: 20.953 m
Height: 4.354 m
Propeller diameter: 17.28 m
Weight empty: 8200 kg
Normal weight: 11200 kg
Maximum weight: 11500 kg
Maximum fuel: 1192 kg
Service ceiling: 2500 m
Maximum speed: 330 km/h
Maximum range: 500 km



# *Mi-26 "Halo"*

***Type: Heavy Transport***

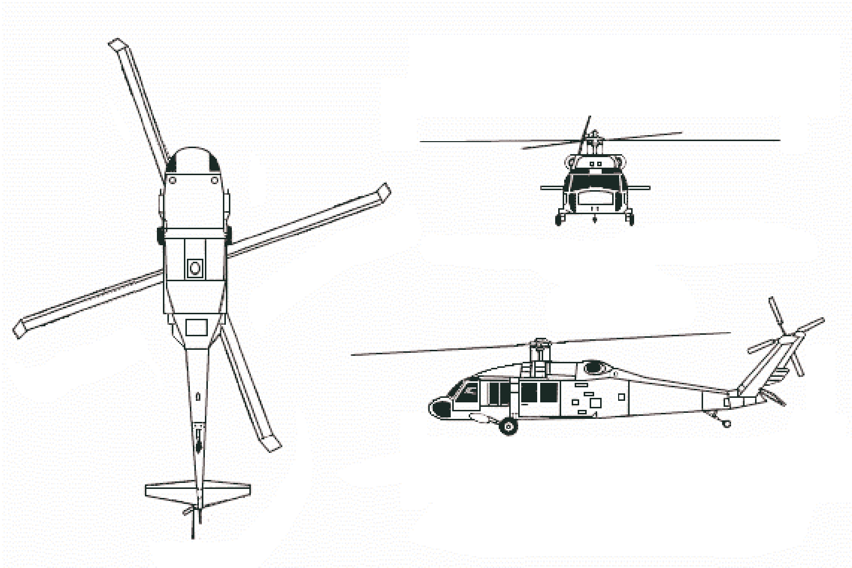
Crew: 2
Length: 40.854 m
Height: 12.9 m
propeller diameter: 31.6 m
Weight empty: 28200 kg
Normal weight: 49600 kg
Maximum weight: 56000 kg
Maximum fuel: 9600 kg
Service ceiling: 1800 m
Maximum speed: 295 km/h
Maximum range: 670 km



# UH-60A "Black Hawk"

**Type: Infantry Squad Transport**

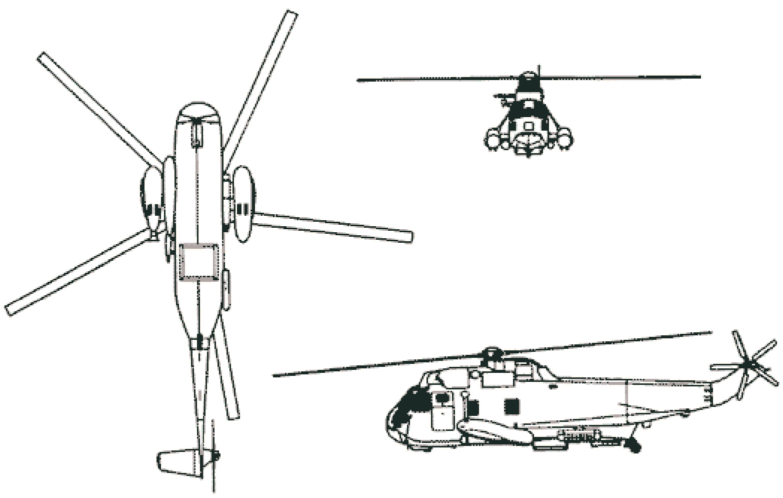
Crew: 2
Length: 18.654 m
Height: 4.893 m
Propeller diameter: 14.712 m
Weight empty: 5735 kg
Normal weight: 9260 kg
Maximum weight: 9980 kg
Maximum fuel: 1157 kg
Service ceiling: 4170 m
Maximum speed: 293 km/h
Maximum range: 600 km



# SH-3H "Sea King"

**Type: Anti-Submarine Warfare**

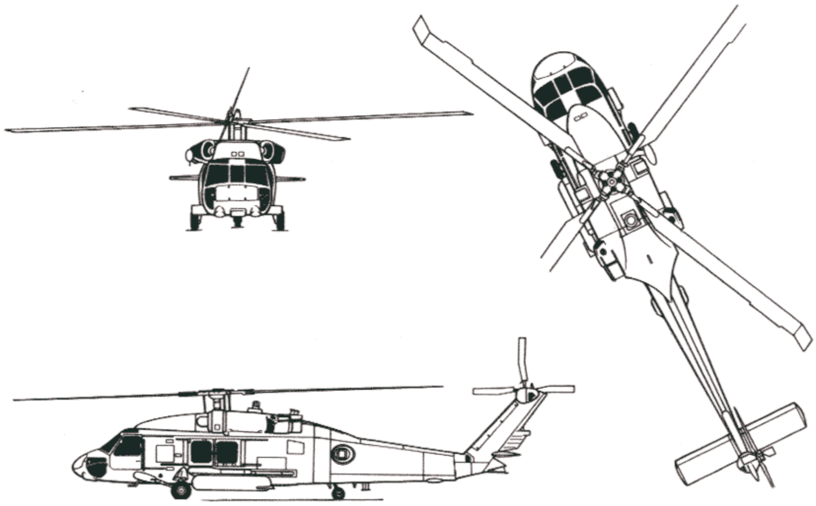
Crew: 2
Length: 30.207 m
Height: 6.807 m
Propeller diameter: 24.946 m
Weight empty: 5600 kg
Normal weight: 9300 kg
Maximum weight: 9525 kg
Maximum fuel: 2544 kg
Service ceiling: 3570 m
Maximum speed: 267 km/h
Maximum range: 1,005 km



# SH-60B "Sea Hawk"

**Type: Anti-Submarine Warfare**

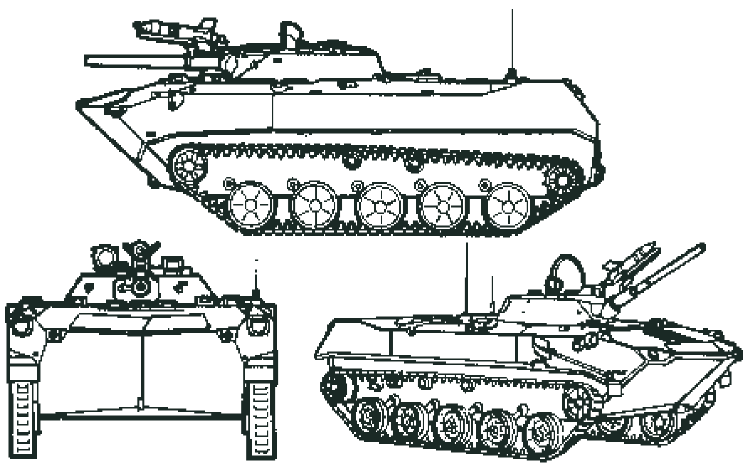
Crew: 2
Length: 18.654 m
Height: 4.893 m
Propeller diameter: 14.712 m
Weight empty: 6190 kg
Normal weight: 9180 kg
Maximum weight: 9925 kg
Maximum fuel: 1157 kg
Service ceiling: 4510 m
Maximum speed: 293 km/h
Maximum range: 480 km



# BMD-1

**Type: Infantry Fighting Vehicle**

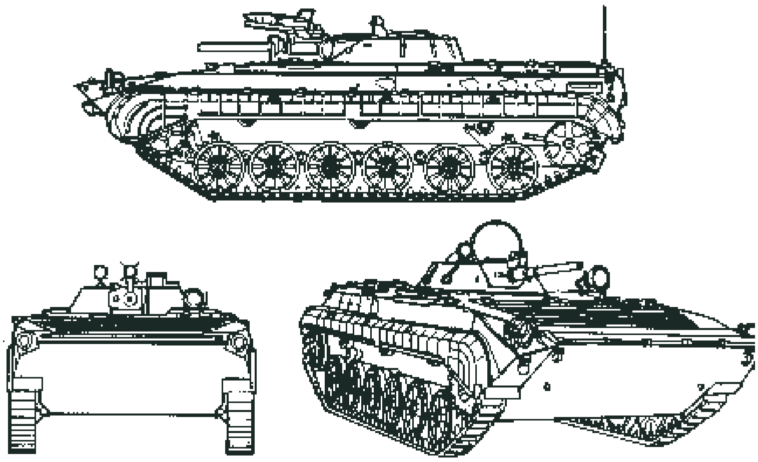
Crew: 3+4
Combat weight: 7,500 kg
Power-to-weight ratio: 32 hp/t
Length: 5.4 m
Width: 2.63 m
Height: 1.62-1.97 m
Ground clearance: 0.1-0.45 m
Engine: 5D-20 V-6 diesel 240 hp
Max road speed: 70 km/h
Max water speed: 10 km/h
Fuel distance: 320 km
Armament:
(main) 1x73 mm 2A28 gun
(coaxial) 1x7.62 mm PKT MG
(forward firing) 2 single 7.62 mm PKT MGs
Ammunition:
(main) 40
(coaxial) 2,000



# BMP-1

***Type: Infantry Fighting Vehicle***

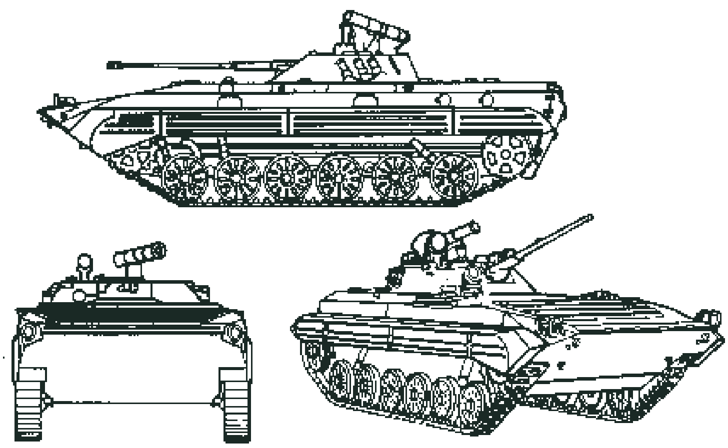
Crew: 3+8
Combat weight: 13,500 kg
Power-to-weight ratio: 22.22 hp/t
Length: 6.74 m
Width: 2.94 m
Height: 2.15 m
Ground clearance: 0.39 m
Engine: UTD-20 V-6 Max road speed: 65 km/h
Max water speed: 7 km/h
Fuel distance: 550-600 km
Armament:
(main) 1x73 mm 2A28 gun
(coaxial) 1x7.62 mm PKT MG
(other) 1 launcher rail for 'Sagger' ATGW
Ammunition:
(main) 40 (coaxial) 2,000 ('Sagger') 4+1
Armour
Hull: (max) 19 mm
Turret: (max) 23 mm



# BMP-2

***Type: Infantry Fighting Vehicle***

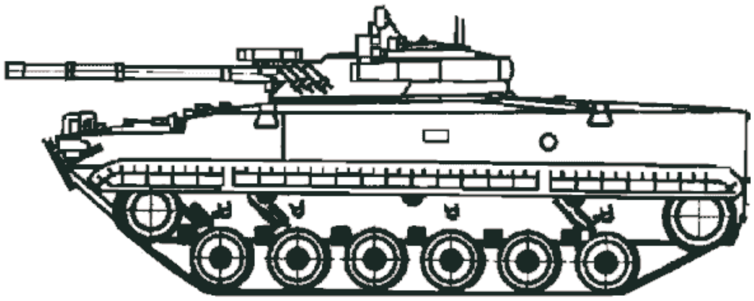
Crew: 3+7
Combat weight: 14300 kg
Power-to-weight ratio: 20.3 hp/t
Length: 6.735 m
Width: 3.15 m
Height: 2.45 m
Ground clearance: 0.42 m
Engine: UTD-20 V-6 diesel 300 hp
Max road speed: 65 km/h
Max water speed: 7 km/h
Fuel distance: 550-600 km
Armament:
(main) 1x30 mm 2A42 cannon
(coaxial) 1x7.62 mm PKT MG
(other) 1 launcher for AT-5 'Spandrel'
or AT-4 'Spigot' ATGW



## BMP-3

***Type: Infantry Fighting Vehicle***

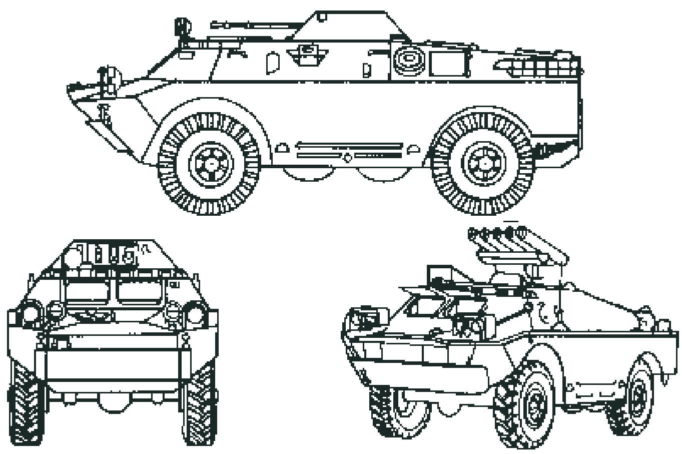
Crew: 10
Length: 7.14 m
Height: 2.45 m
Weight: 18700 kg
Max road speed: 70 km/h
Fuel distance: 600 km
Armament:
(main) 1 X 100 mm 2A70 gun,
(coaxial) 1 X 30 mm 2A72 cannon,
(coaxial) 1 X 7.62 mm PKT MG,
(bow) 2 X 7.62 mm PKT MG,
(smoke grenade dischargers) 2 X 3 81 mm



## BRDM-2

***Type: Amphibious Scout Car***

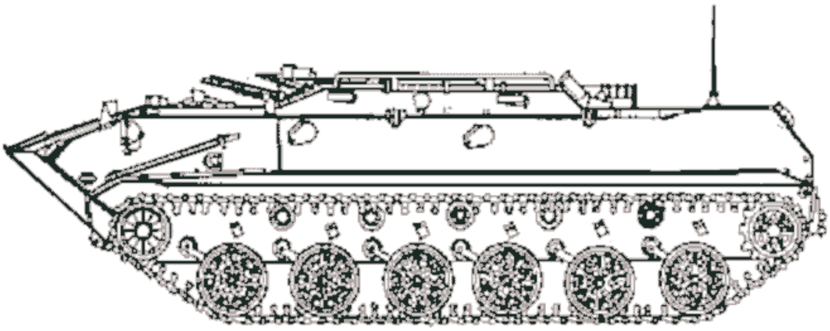
Crew: 4
Configuration: 4x4
Combat weight: 7000 kg
Power-to-weight ratio: 20 hp/t
Length: 5.75 m
Width: 2.35 m
Height: 2.31 m
Ground clearance: 0.43 m
Engine: GAZ-41 V-8 140 hp
Max road speed: 100 km/h
Max water speed: 10 km/h
Fuel distance: 750 km
Armament:
(main) 1x14.5 mm KPVT MG
(coaxial) 1x7.62 mm PKT MG
Ammunition:
(main) 500
(coaxial) 2000
Armour
Hull: (max) 14 mm
Turret: (max) 7 mm



## BTR D

***Type: Armoured Personnel Carrier***

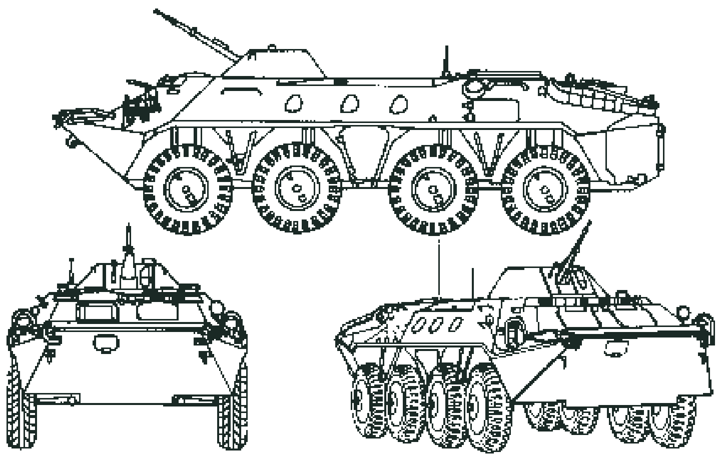
Crew: 11
Length: 5.884 m
Height: 1.66 m
Weight: 6700 kg
Fuel distance: 500 km
Armament: None



## BTR-70

***Type: Armoured Personnel Carrier***

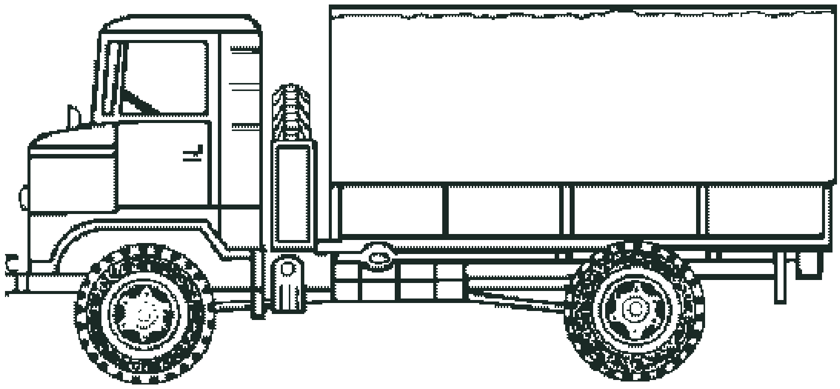
Crew: 2+9
Configuration: 8x8
Combat weight: 11500 kg
Power-to-weight ratio: 20.86 hp/t
Length: 7.535 m
Width: 2.8 m
Height: 2.32 m
Ground clearance: 0.475 m
Engine: 2xZMZ-4905 V-8 120 hp each
Max road speed: 80 km/h
Max water speed: 10 km/h
Fuel distance: 600 km
Armament:
(main) 1x14.5 mm KPVT MG
(coaxial) 1x7.62 mm PKT MG
Ammunition:
(main) 500
(coaxial) 2000



## GAZ-66

***Type: Off-road Military Truck***

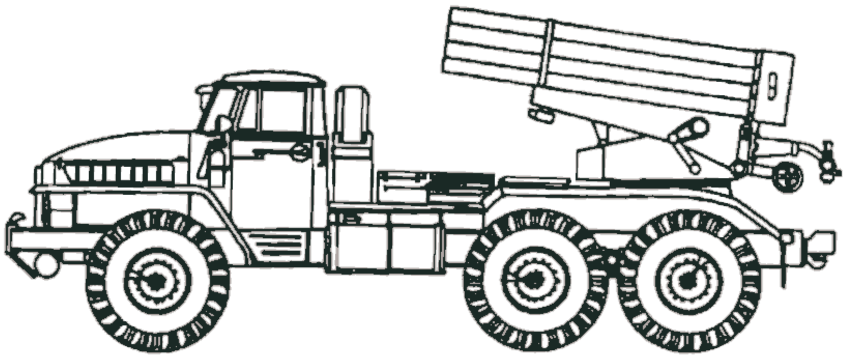
4x4 2-ton truck
Length: 5805mm, width: 2322mm, height (with canvas top): 2520mm
Wheelbase: 3300mm, clearance: 315mm
Weight: 3470 kg unloaded, fuelled
Maximal speed: 90 km/h
Fuel capacity: 2x105 L
Fuel consumption: 24 L/100km under 30-40 km/h



## Grad

***Type: Multiple Rocket System***

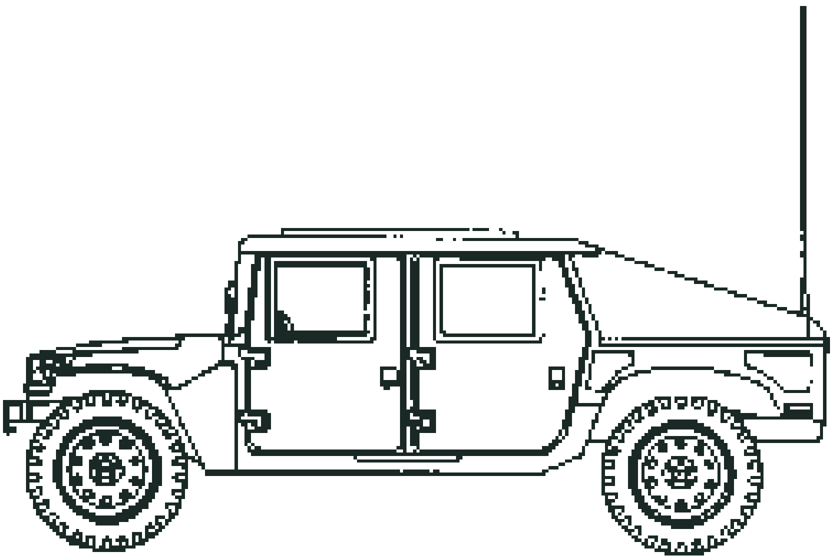
Crew: 6
Chassis: URAL-375
Calibre: 122.4 mm
Number of tubes: 40
Armament: 9 solid propellant rockets
Rate of fire: 40 rds/20 s
Reload time: 8 min
Elevation: 0-55°
Traverse: 120° left, 60° right
Time into action: 2.5 min
Time out of action: 0.5 min
Combat weight: 13700 kg



# Hummer

***Type: Multipurpose Wheeled Vehicle***

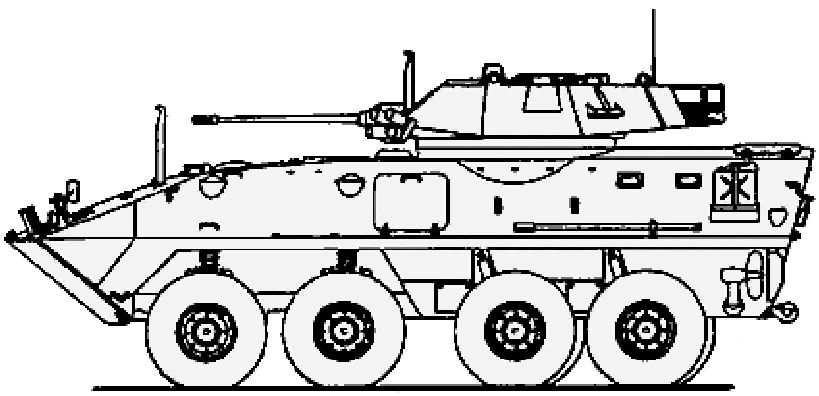
Cab seating: 1+3
Configuration: 4x4
Weight :
(empty) 2855 kg
(loaded) 3990 kg
Max load: 1135 kg
Towed load: 1542 kg
Length: 4.72 m
Width: 2.18 m
Height: 1.83 m
Ground clearance: 0.41 m
Engine: GM V-8 diesel 150 hp
Max road speed: 113 km/h
Fuel distance (road): 482 km
Armament: 1x12.7 mm sq m MG



# LAV-25

***Type: Light Armoured Vehicle***

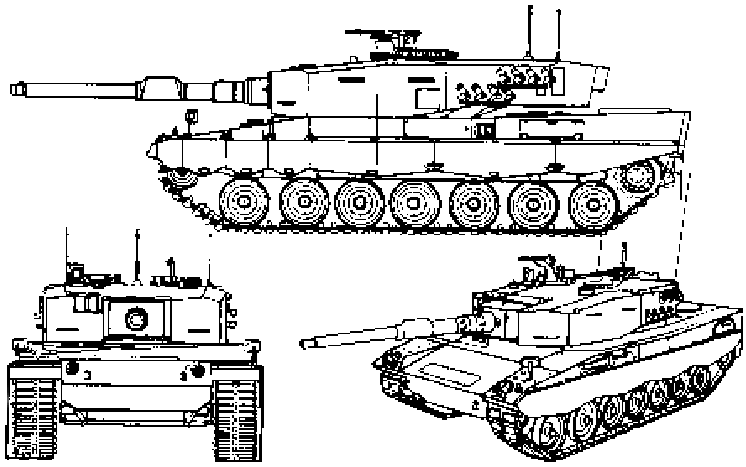
Crew: 3+6
Configuration: 8x8
Combat weight: 12792 kg
Power-to-weight ratio: 21.49 hp/t
Length: 6.393 m
Width: 2.499 m
Height: 2.692 m
Engine: 6V-53T V-6 diesel 275 hp
Max road speed: 100 km/h
Max water speed: 9.6 km/h
Fuel distance: 668 km
Armament:
(main) 1x25 mm sq m42 cannon
(coaxial) 1x7.62 mm sq m40 MG
Ammunition:
(main) 210+420 (stowed)
(coaxial) 420+1,200 (stowed)



## Leopard-2

*Type: Main Battle Tank*

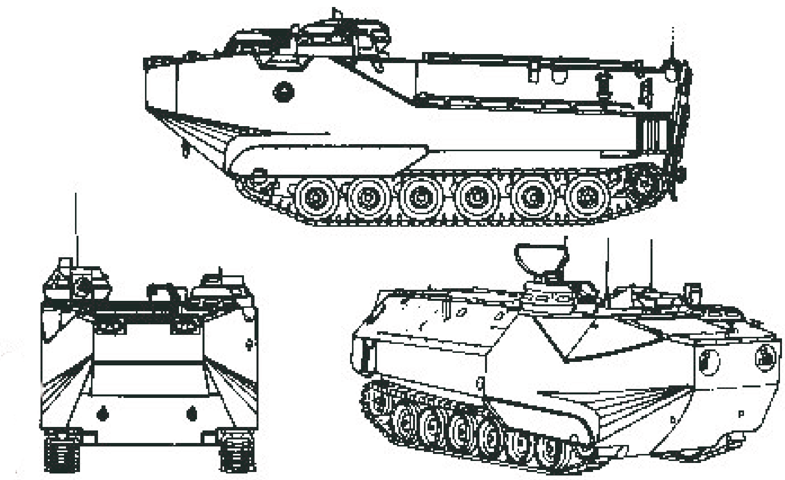
Crew: 4
Combat weight: 55150 kg
Power-to-weight ratio: 27.0 hp/t
Length: 9.668 m
Width: 3.7 m
Height: 2.48 m
Ground clearance: 0.487 m
Engine: MTU MB 873 Ka-501 V-12 diesel 1500 hp
Max road speed: 72 km/h
Fuel distance: (road) 550 km
Armament:
(main) 1x120 mm gun
(coaxial) 1x7.62 mm MG3 MG
(anti-aircraft) 1x7.62 mm MG3 MG
Ammunition:
(main) 42
(MG) 4750



## LVTP-7

*Type: Amphibious Assault Vehicle*

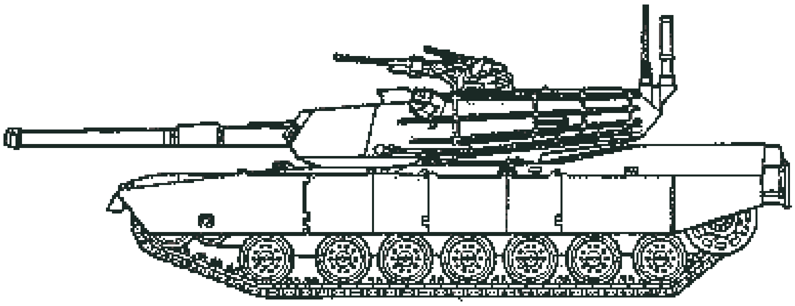
Crew: 3+25
Combat weight: 22838 kg
Power-to-weight ratio: 17.51 hp/t
Length: 7.943 m
Width: 3.27 m
Height: 3.263 m
Ground clearance: 0.406 m
Engine: 8V-53T V-8 diesel 400 hp
Max road speed: 64 km/h
Max water speed: 13.5 km/h
Armament:
1x12.7 mm sq m MG
Ammunition: 1000
Armour 12-45 mm

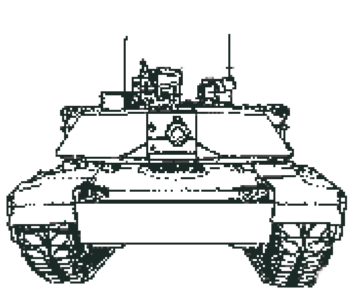


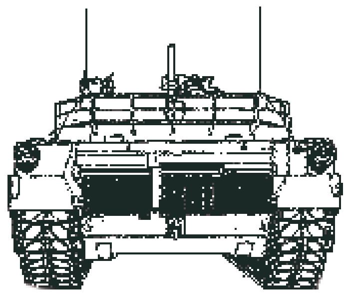
# M-1 Abrams

***Type: Main Battle Tank***

Crew: 4
Combat weight: 57154 kg
Power-to-weight ratio: 26.24 hp/t
Length: 9.828 m
Width: 3.657 m
Height: 2.438 m
Ground clearance: 0.432 m
Engine: AGT 1500 gas turbine 1500 hp
Max road speed: 66.7 km/h
Fuel distance: (road) 465 km
Armament:
(main) 1x120 mm gun
(coaxial) 1x7.62 mm MG
(anti-aircraft commander) 1x12.7 mm MG
(anti-aircraft loader) 1x7.62 mm MG



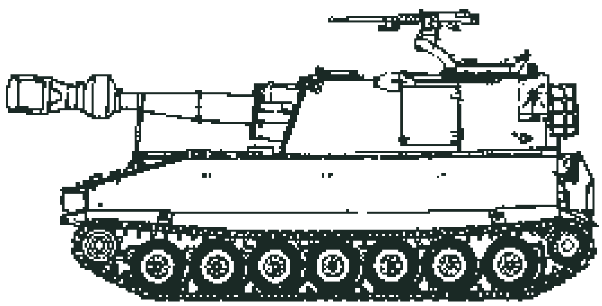


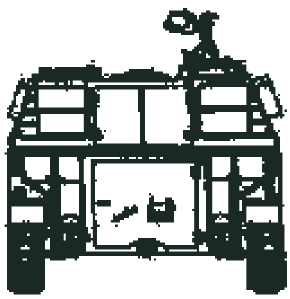


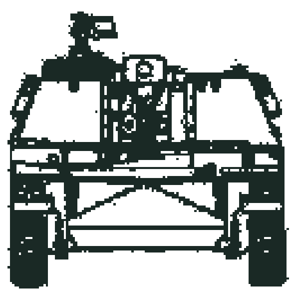
# M-109

***Self-propelled Howitzer***

Crew: 6
Combat weight: 24948 kg
Power-to-weight ratio: 16.23 hp/t
Length: 9.12 m
Width: 3.15 m
Height: 2.8 m
Ground clearance: 0.46 m
Engine: 8V-71T V-8 diesel 405 hp
Max road speed: 56.3 km/h
Fuel distance: (road) 349 km
Armament:
(main) 1x155 mm M185 howitzer
(anti-aircraft) 1x12.7 mm MG
Ammunition:
(main) 34 plus 2 CLGP
(12.7 mm) 500



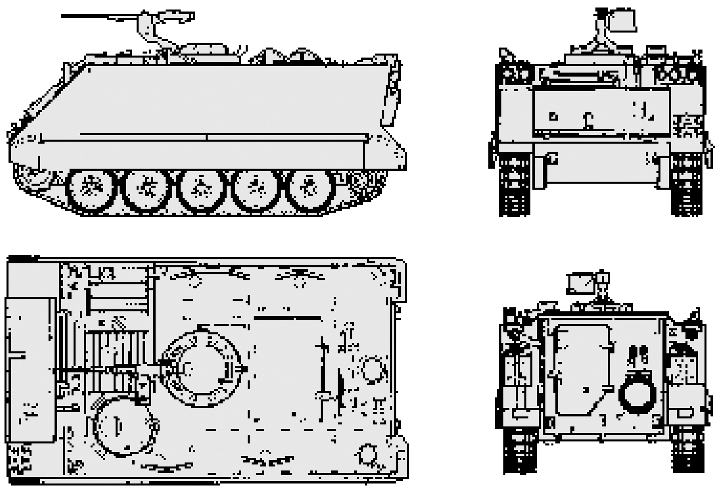




## M-113

***Type: Armoured Personnel Carrier***

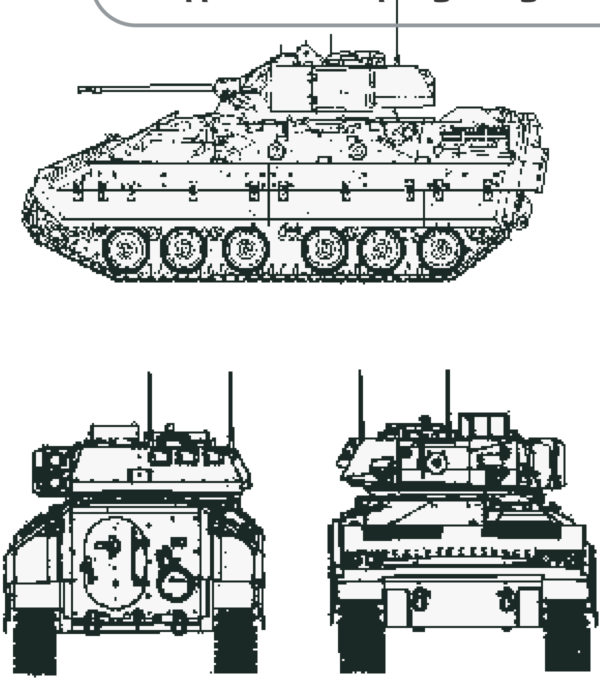
Crew: 2+11
Combat weight: 11253 kg
Power-to-weight ratio: 18.51 hp/t
Length: 4.863 m
Width: 2.686 m
Height: 2.52 m
Ground clearance: 0.43 m
Engine: 6V-53 V-6 diesel 212 hp
Max road speed: 60.7 km/h
Max water speed: 5.8 km/h
Armament:
1x12.7 mm sq m MG
Ammunition: 2000
Armour 12-44 mm



## M2 Bradley

***Type: Infantry Fighting Vehicle***

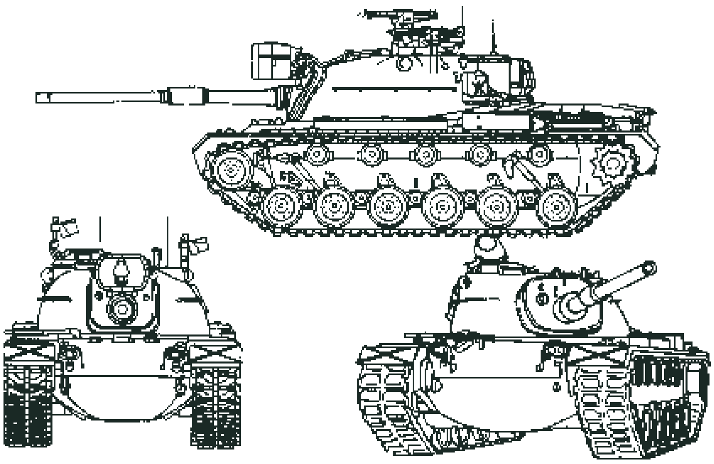
Crew: 9
Length: 6.45 m
Height: 2.58 m
Weight: 21300 kg
Max road speed: 66 km/h
Fuel distance: 490 km
Armament:
(main) 1 X 25 mm sq m42 cannon,
(coaxial) 1 X 7.62 mm sq m40C MG,
(ATWG) 2-tube TOW launcher,
(firing port guns) 5.56 mm
[nil]



# M-48

**Type: Medium Tank**

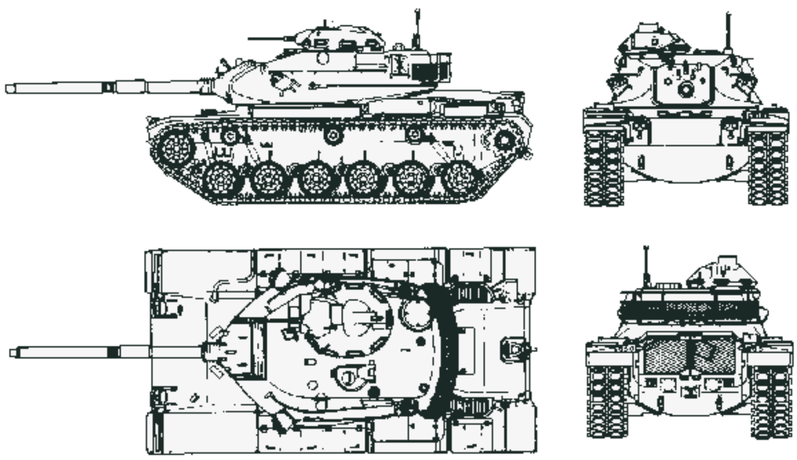
Crew: 4
Length: 9.306 m
Height: 3.086 m
Weight: 48987 kg
Max road speed: 48 km/h
Fuel distance: 499 km
Armament:
(main) 1 X 105 mm M68 gun,
(coaxial) 1 X 7.62 mm MG,
(anti-aircraft) 2 X 7.62 mm MG



# M-60

**Type: Medium Tank**

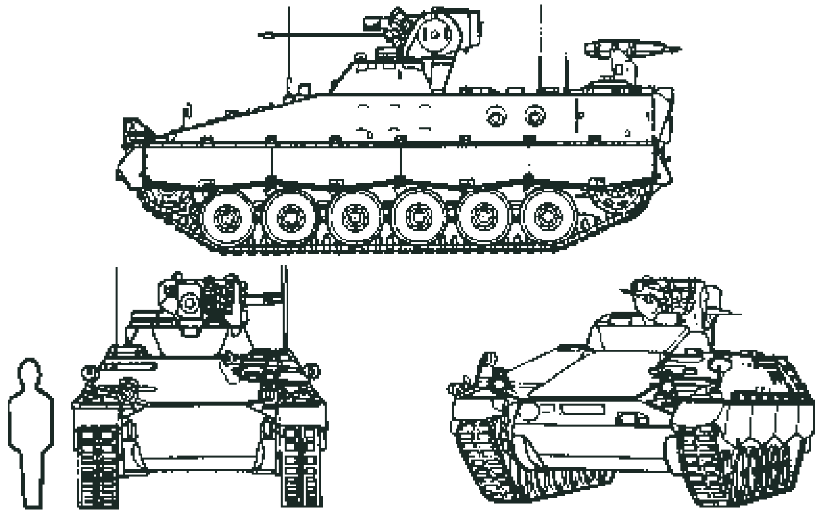
Crew: 4
Length: 9.436 m
Height: 3.27 m
Weight: 52617 kg
Max road speed: 48 km/h
Fuel distance: 480 km
Armament:
(main) 1 X 105 mm M68 gun,
(coaxial) 1 X 7.62 mm MG,
(anti-aircraft) 1 X 12.7 mm MG



# Marder

***Type: Infantry Fighting Vehicle***

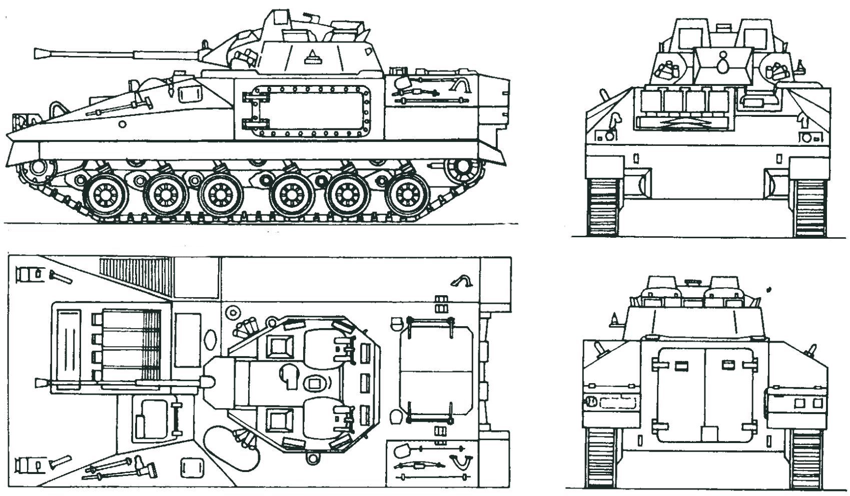
Crew: 9
Combat weight: 29,207 kg
Power-to-weight ratio: 20.54 hp/t
Length: 6.79 m
Width: 3.24 m
Height: 2.985 m
Ground clearance: 0.44 m
Engine: MTU MB 833 Ea-500 V-6 diesel 600 hp
Max road speed: 75 km/h
Fuel distance (road): 520 km
Armament:
(main) 1x20 mm MK 20 Rh 202 cannon
(coaxial) 1x7.62 mm MG3 MG
Ammunition:
(main) 1250
(coaxial) 5000



# MCV-80 Warrior

***Type: Infantry Fighting Vehicle***

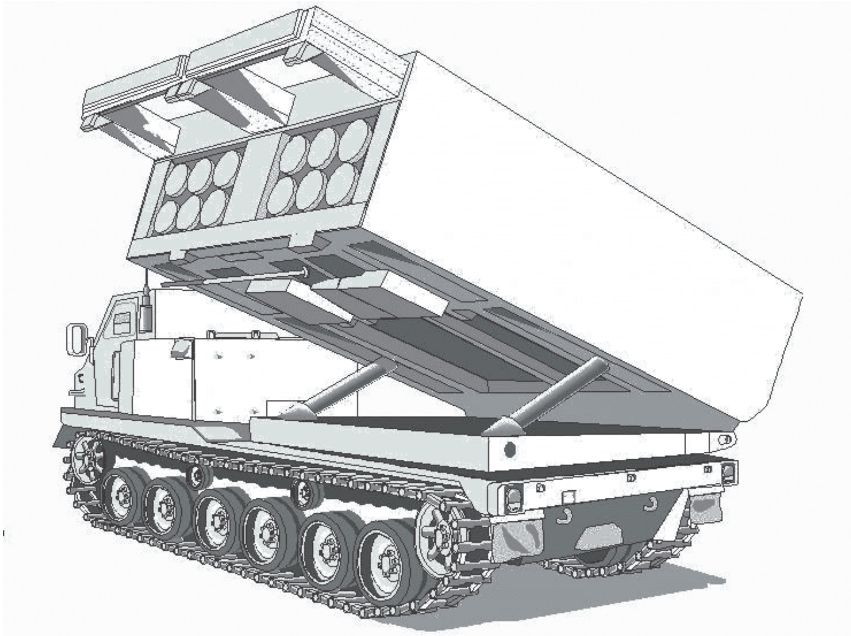
Crew: 10
Length: 6.33 m
Height: 2.76 m
Weight: 23500 kg
Max road speed: 75 km/h
Fuel distance (road): 500 km
Armament:
(main) 1 X 30 mm L21A1 cannon,
(coaxial) 1 X 7.62 mm L94A1 MG,
Ammunition:
(main) 228
(coaxial) 2200



# MLRS

*Type: Multiple Rocket Launcher*

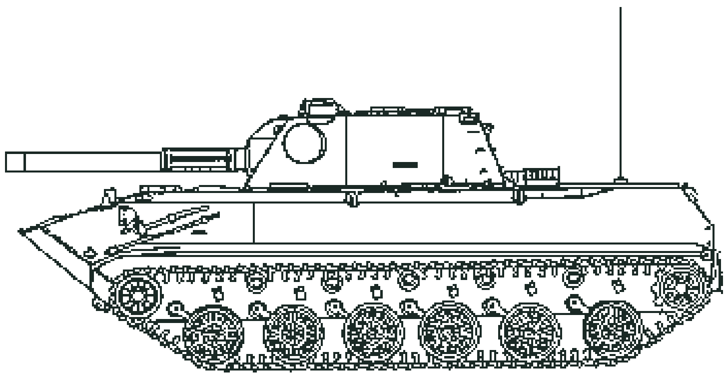
Crew: 3
Length: 6.972 m
Height: 2.617 m
Weight: 25191 kg
Max road speed: 64 km/h
Fuel distance: 483 km



# SAO 2S9 Nona

*Type: Self-propelled Howitzer/Mortar*

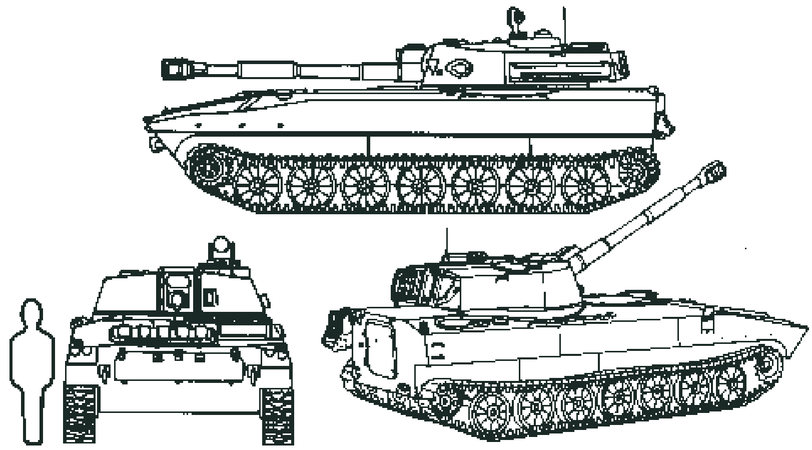
Crew: 4
Combat weight: 8,700 kg
Power-to-weight ratio: 27.58 hp/t
Length: 6.02 m
Width: 2.63 m
Height: 2.3 m
Ground clearance: 0.1-0.45 m
Max road speed: 60 km/h
Max water speed: 9 km/h
Fuel distance:
(road) 500 km
(water) 75-90 km
Armament: 1x120 mm 2A60 mortar
Ammunition: 25
Gun elevation/depression: +80°/-4°
Turret traverse: 35° left/ 35° right



# SAU 2S1 Gvozdika

***Type: Self-Propelled Howitzer***

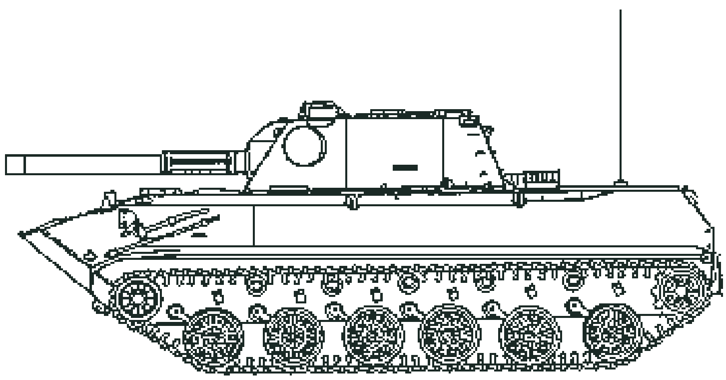
Crew: 4
Length: 7.26 m
Height: 2.285 m
Combat weight: 15700 kg
Engine: YaMZ-238 diesel 285 hp
Max road speed: 60 km/h
Fuel distance: 500 km
Armament: 1x122 mm D-32 gun
Ammunition: 40



# SAU 2S19 Msta

***Type: Self-propelled Artillery***

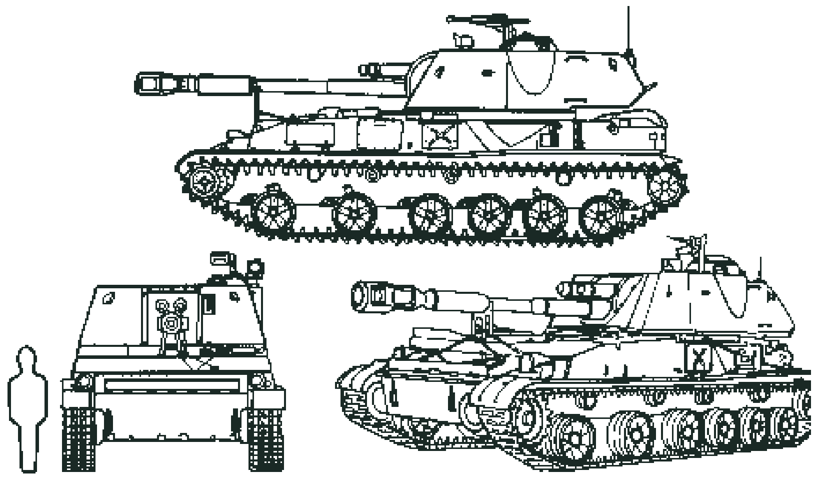
Crew: 5
Combat weight: 42000 kg
Power-to-weight ratio: 20.0 hp/t
Length: 11.917 m
Width: 3.584 m
Height: 2.985 m
Ground clearance: 0.435 m
Max road speed: 60 km/h
Fuel distance: 500 km
Armament:
(main) 1x152 mm 2A64 gun
(anti-aircraft) 1x12.7 mm NSVT MG
Ammunition:
(main) 50
(12.7 mm) 300
Gun elevation/depression: +68°/-4°2
Turret traverse: 360°



# SAU 2S3 Akatsia

**Type: Self-Propelled Howitzer**

Crew: 4+2 in ammunition carrier
Combat weight: 27500 kg
Power-to-weight ratio: 17.33 hp/t
Length: 8.4 m
Width: 3.25 m
Height: 3.05 m
Ground clearance: 0.45 m
Max road speed: 60 km/h
Fuel distance:
(road) 500 km
(cross-country) 270 km
Armament:
(main) 1x152 mm 2A33 gun
(anti-aircraft) 1x7.62 mm PKT MG
Rate of fire:
(max) 4 rds/min
Gun elevation/depression: +60°/-4°
Turret traverse: 360°



# SAU Bereg

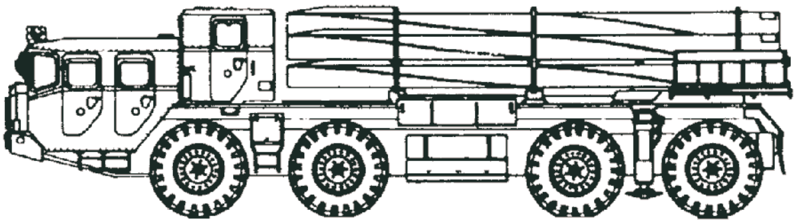
**Type: Self-propelled Coastal Artillery**

Crew: 8
Configuration: 8x8
Armament: 1x130 mm gun
Elevation: -5 to +50°
Traverse: 120° left and right
Rate of fire: 10 rds/min
Basic load: 48 rounds
Combat weight: 43700 kg
Length: 12.95 m
Width: 3.2 m
Height: 3.925 m
Max road speed: 60 km/h
Fuel distance (road): 650 km

## Smerch

***Type: Multiple Rocket System***

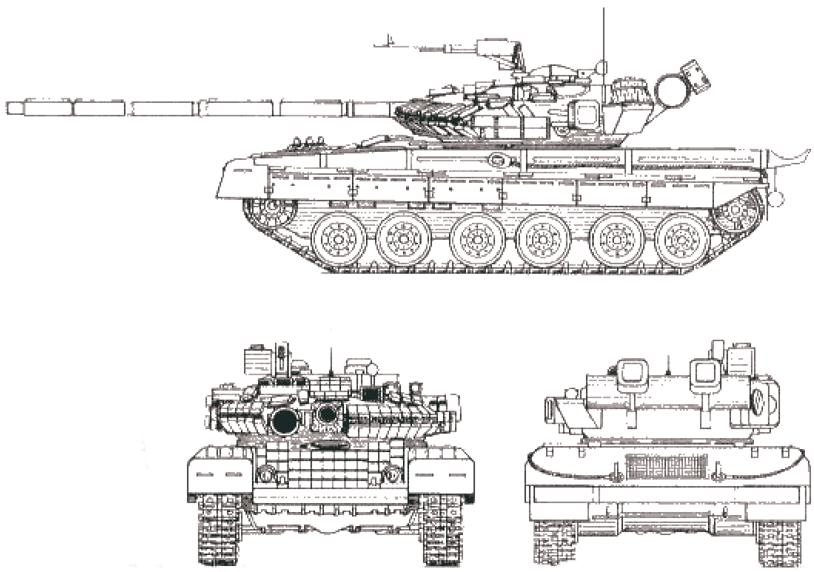
Crew: 4
Calibre: 300 mm
Number of tubes: 12
Armament: 9M55K solid propellant rocket
Rate of fire: 12 rds/38-40 s
Time into action: 3 min
Time out of action: 3 min
Elevation: 0-55°
Traverse: 30° left and right
Configuration: 8x8
Combat weight: 43700 kg
Length: 12.1 m
Width: 3.05 m
Height: 3.05 m
Ground clearance: 0.44 m
Engine: V-12 diesel 518 hp
Max road speed: 60 km/h
Fuel distance (road): 850 km



## T-80

***Type: Main Battle Tank***

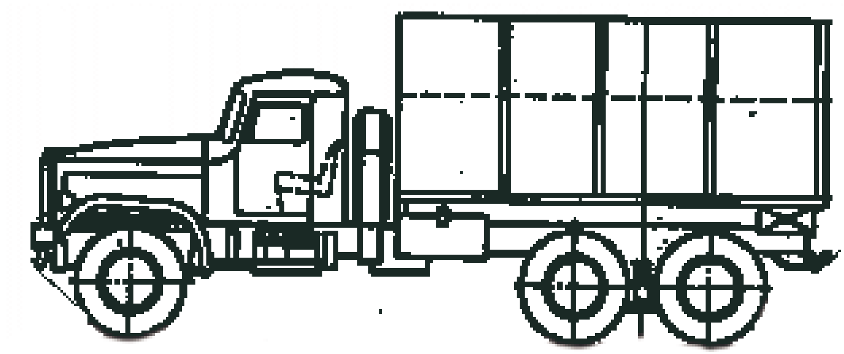
Crew: 3
Combat weight: 46000 kg
Power-to-weight ratio: 23.9 hp/t
Length: 9.656 m
Width: 3.589 m
Height: 2.202 m
Ground clearance: 0.446 m
Engine: 6TF O-6 diesel 1100 hp
Max road speed: 70 km/h
Fuel distance: (road) 550 km
Armament:
(main) 1x125 mm 2A46M gun
(coaxial) 1x7.62 mm PKT MG
(anti-aircraft) 1x12.7 mm NSVT MG
Ammunition:
(main) 39 (28 in automatic loader)
(coaxial) 1250
(anti-aircraft) 450



# Ural-375

*Type: Cargo truck*

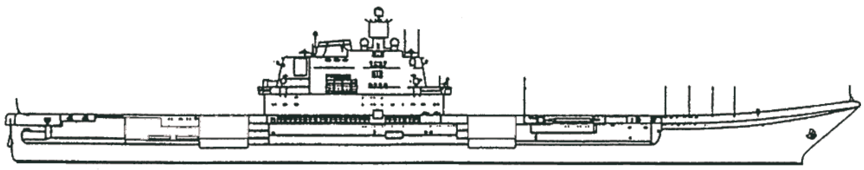
Cab seating: 1+2
Configuration: 6x6
Weight : (empty) 8400 kg
Max load: 4800 kg
Towed load:
(road) 10000 kg
(cross-country) 5000 kg
Length: 7.35 m
Width: 2.69 m
Height: 2.68 m
Ground clearance: 0.4 m
Engine: ZIL-375 V-8 180 hp
Max road speed: 80 km/h
Fuel distance (road): 570 km



# Admiral Kuznetsov

*Type: Aircraft Carrier*

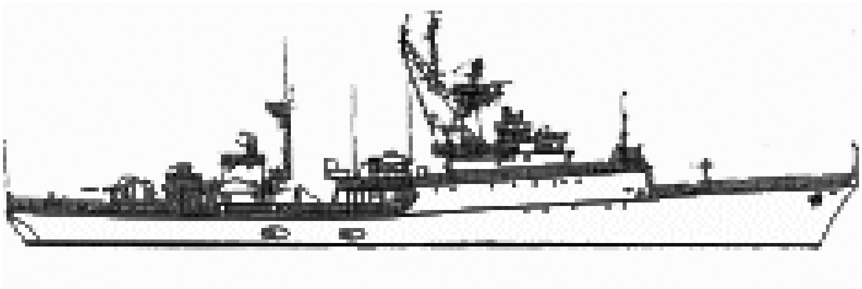
Displacement, tons: 55000 standard 67500 full load
Dimensions, m: 302,5x72,3x10,5
Speed, knots: 30
Range, miles: 3850 at 29 kts, 8500 at 18 kts
Complement: 2590
Armament: 12 SSM Granit, 4x6 SAM Kynshal, 8 SAM Kashtan, 6x6-30mm AK-630 gun, 36 Su-33, 16 Ka-27



# Albatros

***Type: Frigate***

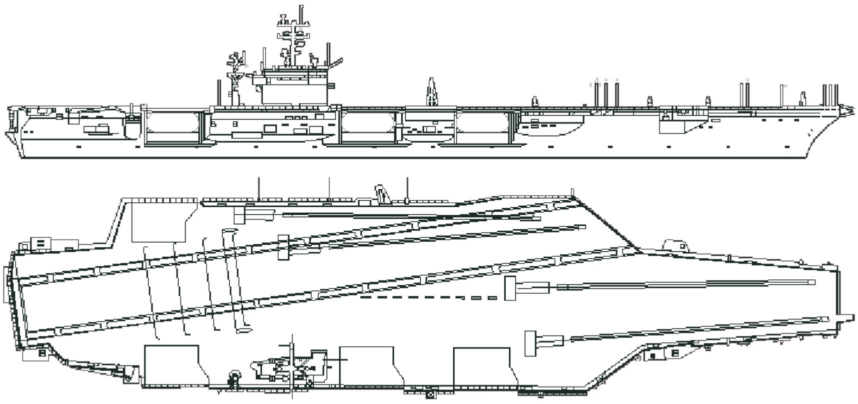
Displacement, tons: 954 standard 1070 full load
Dimensions, m: 71,2x10,15x3,72
Speed, knots: 32
Range, miles: 950 at 27 kts, 2700 at 14 kts
Complement: 79
Armament: 1x2 SAM Osa, 1x2 AK-176 gun, 1x6-30mm AK-630 gun



# CVN-70 Carl Vinson

***Type: Aircraft Carrier***

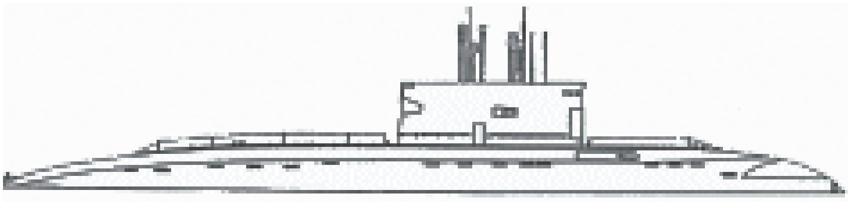
Displacement, tons: 72916 full load
Dimensions, m: 332,9x76,8x11,5
Speed, knots: 30
Range, miles: 3850 at 29 kts, 8500 at 18 kts
Complement: 3184
Armament: 3 SAM Mk 29 Sea Sparrow, 4x6-20mm Vulcan Phalanx gun, 20 F-14, 36 F/A-18, 4 EA-6B, 4 E-2C, 8 S-3A/B



## Kilo

**Type: Patrol Submarine**

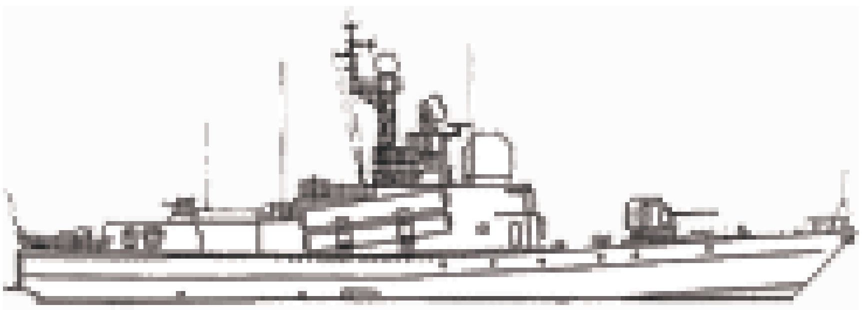
Displacement, tons: 2325 standard 3076 full load
Dimensions, m: 72,6x9,9x6,6
Speed, knots: 12/18
Range, miles: 400 at 10 kts dived, 6000 at 7 kts shorting
Complement: 53
Armament: 8 SAM Igla-1, 6 - 21in tubes



## Molniya

**Type: Corvette**

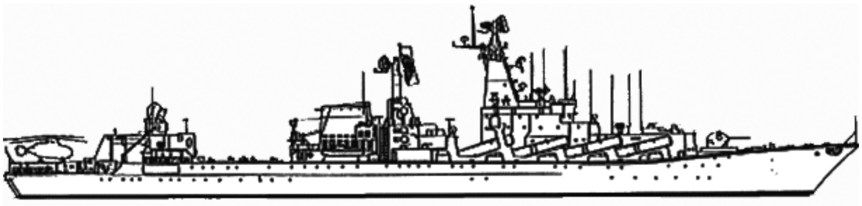
Displacement, tons: 398 standard 469 full load
Dimensions, m: 56,1x10,2x2,65
Speed, knots: 42
Range, miles: 450 at 36 kts, 2400 at 13 kts
Complement: 44
Armament: 2x2 SSM Mosquit, 1x2 SAM Strela-3, 1x2 AK-176 gun, 2x6-30mm AK-630 gun



## Moscow

***Type: Cruiser***

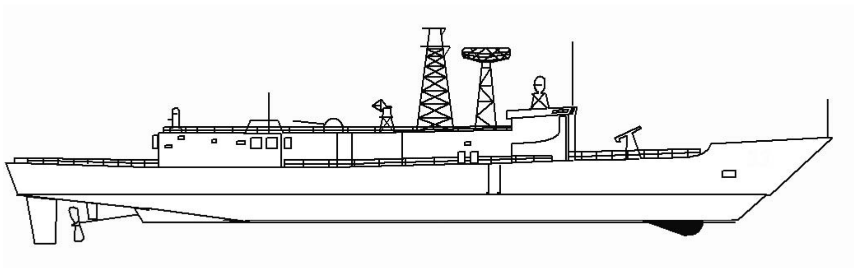
Displacement, tons: 9800 standard 11300 full load
Dimensions, m: 186x20,8x8,3
Speed, knots: 32
Range, miles: 2500 at 30 kts, 6800 at 18 kts
Complement: 476
Armament: 16 SSM Bazalt, 8x8 SAM Fort, 2x2 SAM Osa, 1x2 AK-130 gun, 6x6-30mm AK-630 gun, 1 Ka-27



## Oliver H. Perry

***Type: Frigate***

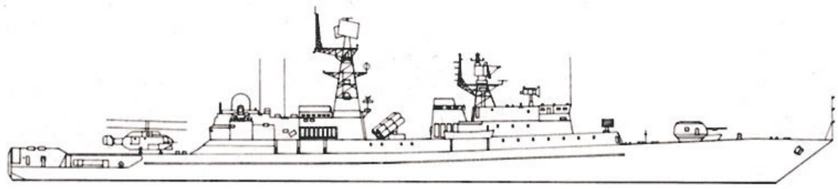
Type: Frigate
Displacement, tons: 2750 standard 4100 full load
Dimensions, m: 138,1x13,7x7,5
Speed, knots: 29
Range, miles: 4500 at 20 kts
Complement: 206
Armament: 2x4 SSM Harpoon, SAM Standard, 1x76 OTO Melara gun, 1x6-20mm Vulcan Phalanx gun, 2 SH-60B



# *Neustrashimy*

***Type: Frigate***

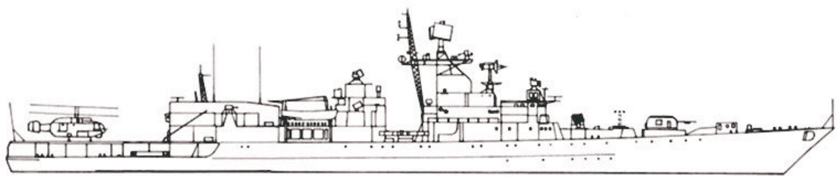
Crew: 210
Displacement, tons: 4250 full, 3450 standard
Dimensions, m: 131, 123x15.5x4.8
Speed, knots: 32
Range, miles: 4500 at 16 knots
Armament: 4x8 SAM Kynshal, 6 533mm torpedoes, 2 SAM Kashtan,
1 100mm AK-100, 2x6 30mm AK-630, 12 A/S mortars RBU-6000, 1 Ka-27 Helix



# *Rezky*

***Type: Frigate***

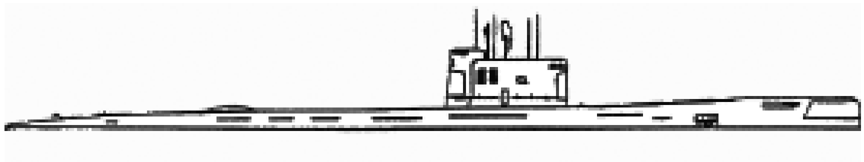
Displacement, tons: 2735 standard 3190 full load
Dimensions, m: 123,1x14,2x7,2
Speed, knots: 32
Range, miles: 1240 at 32 kts, 5125 at 14 kts
Complement: 180
Armament: 2x4 A/S Rastrub, 2x2 SAM Osa, 2x1 AK-100 gun



## Som

***Type: Patrol Submarine***

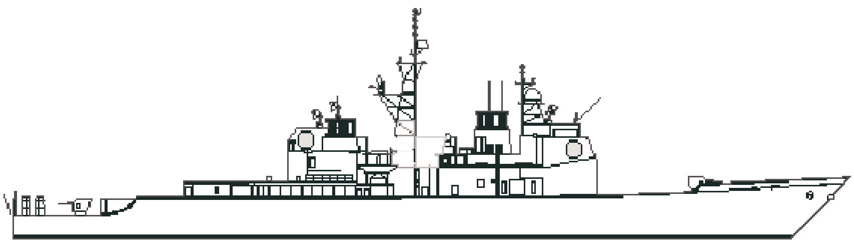
Displacement, tons: 2750 standard 3546 full load
Dimensions, m: 90,2x8,6x5,9
Speed, knots: 13/16
Range, miles: 450 at 2 kts dived, 6000 at 7 kts shorting
Complement: 78
Armament: 6 -21in tubes



## Ticonderoga

***Type: Guided Missile Frigate***

Displacement, tons: 7650 standard 9900 full load
Dimensions, m: 172,8x16,8x9,5
Speed, knots: 34
Range, miles: 3000 at 32 kts, 9000 at 15 kts
Complement: 390
Armament: SLCM/SSM Tomahawk, 2x4 SSM Harpoon, SAM Standard, A/S ASROC, 2x127 FMC 5 gun, 2x6-20mm Vulcan Phalanx gun, 2 SH-60B



# *Avenger*

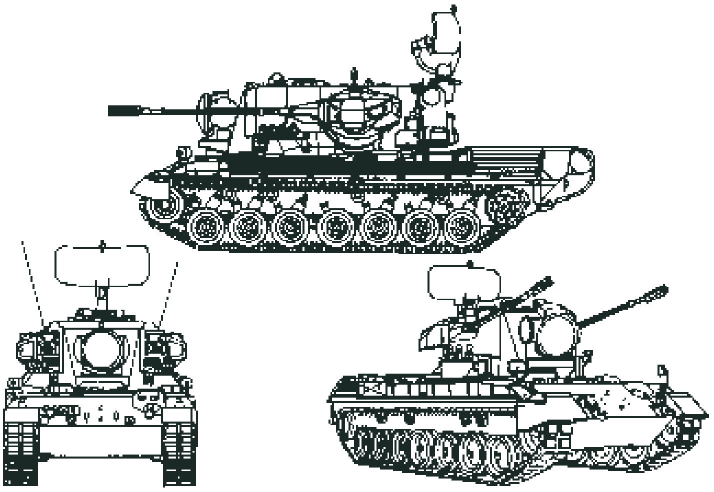
***Type: Low Level Air Defence System***

Crew: 2
Configuration: 4x4
Combat weight: 3900 kg
Length: 4.953 m
Width: 2.184 m
Height: 2.59 m
Ground clearance: 0.406 m
Engine: GM V-8 diesel 150 hp
Max road speed: 105 km/h
Fuel distance: 563 km
Armament:
2x4 Stinger SAMs
1x12.7 mm sq m MG
Gun elevation/depression:
+70°/-10°
Turret traverse: 360°
Launch max speed: Mach 4
Max effective range: 7000 m
Min effective range: 300 m

# *Gepard*

***Type: Self-propelled Anti-Aircraft***

Crew: 3
Engine: MTU MB 838 Ca
M500 V-10 diesel 830 hp
Max road speed: 65 km/h
Fuel distance:
(road) 550 km
(cross-country) 400 km
Combat weight: 47300 kg
Power-to-weight ratio: 17.54
hp/t
Ground pressure: 0.95
kg/sq.cm
Length: 7.73 m
Width: 3.37 m
Height: 4.03 m
Armament:
2x35 mm KDA cannon
Ammunition: 620 rounds
Gun elevation/depression:
+85°/-10°
Turret traverse: 360°



# Hawk

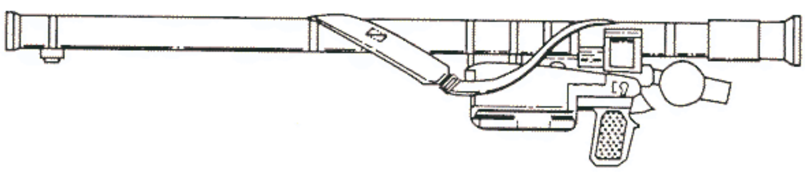
***Type: Low-to-Medium Air Defence***

Armament: 3x SAMs
Launch weight: 584 kg
Warhead: 54 kg HE
Max speed: Mach 2.7
Max effective range: 32000 m
Min effective range: 2000 m
Max effective altitude: 13700 m
Min effective altitude: 60 m

# Igla "Gimlet"

***Type: Low-Altitude SAM System***

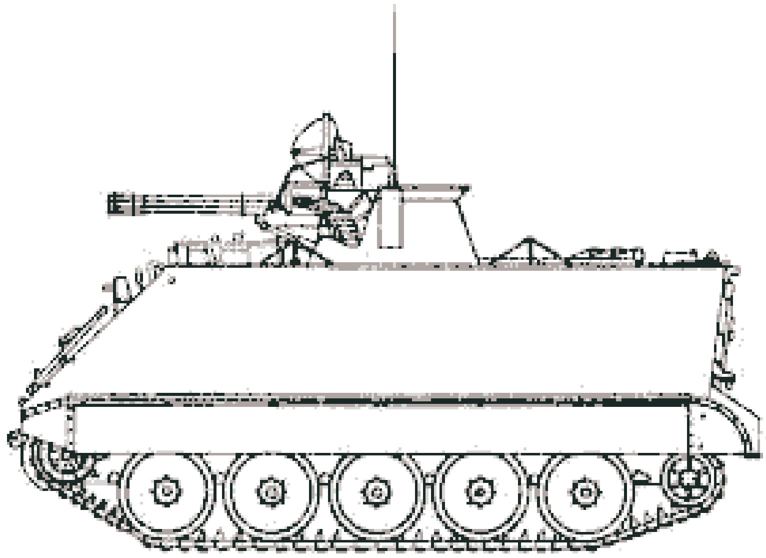
Length (missile): 1.52 m
Diameter (missile): 0.07 m
Wingspan: 0.091 m
Weight (launcher complete): 15.7 kg
Warhead weight: 3.0 kg
Max speed: Mach 2.2
Max range: 8000 m
Max effective range:
(FIM-92A) greater than 4000 m
(FIM-92B/C) greater than 4500 m
Min effective range: 200 m
Max altitude:
(FIM-92A) 3500 m
(FIM-92B/C) 3800 m
Min altitude: effectively ground level



# M-163 Vulcan

**Type: Self-propelled Anti-Aircraft**

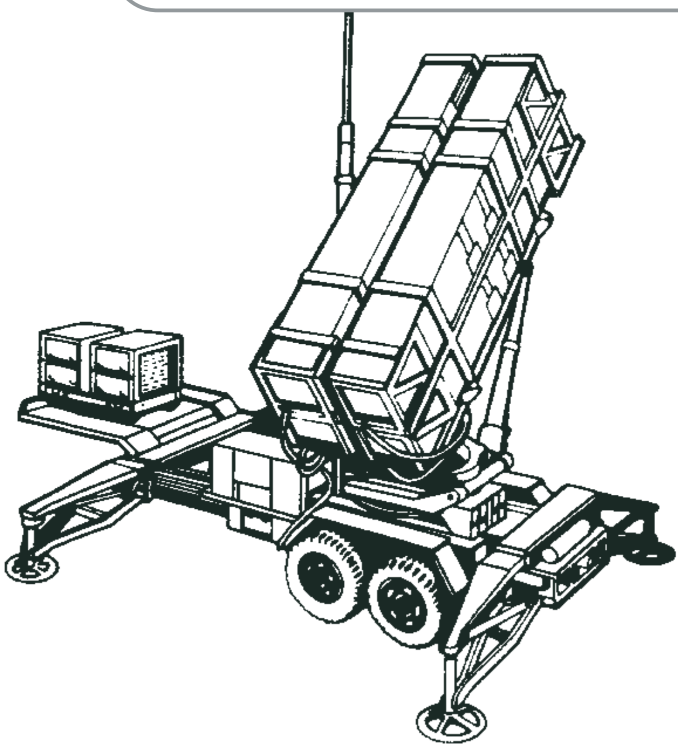
Crew: 4
Combat weight: 12310 kg
Power-to-weight ratio: 17.46 hp/t
Length: 4.86 m
Width: 2.85 m
Height: 2.736 m
Ground clearance: 0.406 m
Engine: 6V-53 V-6 diesel 215 hp
Max road speed: 67.6 km/h
Max water speed: 5.6 km/h
Fuel distance: 483 km
Armour: 12-38 mm
Armament: 1x6 barrel 20 mm cannon
Ammunition: 2280 rounds
Max rate power traverse: 60°/s
Max rate power elevation: 45°/s
Gun elevation/depression: +80°/-5°



# Patriot

**Type: Medium-to-High Air Defence**

Armament: 4x MIM-104 SAMs
Turret traverse: -180° to +180°
Launch weight: 700 kg
Warhead: 73 kg HE
Max speed: Mach 5
Max effective range: 160000 m
Min effective range: 3000 m
Max effective altitude: 24240 m
Min effective altitude: 60 m



## Roland

***Type: Low Altitude SAM System***

Crew: 3
Max road speed: 70 km/h
Fuel distance: 520 km
Combat weight: 32500 kg
Power-to-weight ratio: 18.5 hp/t
Length: 6.915 m
Width: 3.24 m
Height: 2.92 m
Ground clearance: 0.44 m
Armament: 2 Roland-2 SAMs
Launch weight: 66.5 kg
Warhead: 6.5 kg HE
Max speed: 500 m/s
Max effective range: 6300 m
Min effective range: 500 m
Max effective altitude: 5500 m
Min effective altitude: 10 m
Reload time (from magazines): 6 s

## SA-6 "Kub"

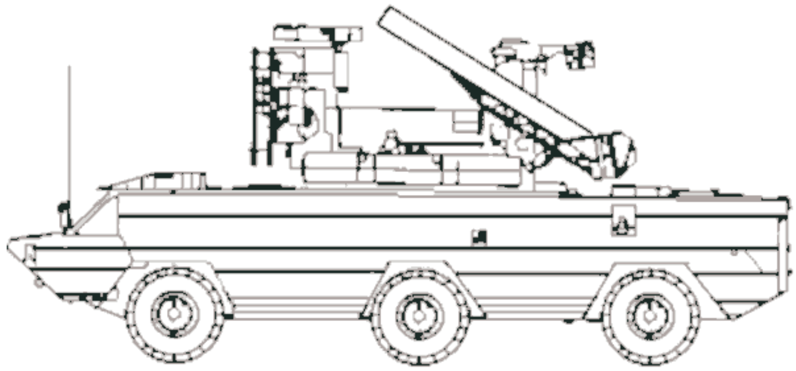
***Type: Low-to-Medium-Altitude SAM***

Crew: 3
Engine: V-6R V-6 diesel 240 hp
Max road speed: 44 km/h
Fuel distance: 260 km
Combat weight: 14000 kg
Length: 7.389 m
Width: 3.18 m
Height: 3.45 m
Ground clearance: 0.4 m
Armament: 3 SA-6 (3M9M) missile
Launch weight: 599 kg
Warhead: 59 kg HE
Max speed: Mach 2,8
Max effective range:24000 m
Min effective range: 4000 m
Max effective altitude: 14000 m
Min effective altitude: (radar mode) 100 m

# SA-8 "Osa"

***Type: Low-Altitude SAM***

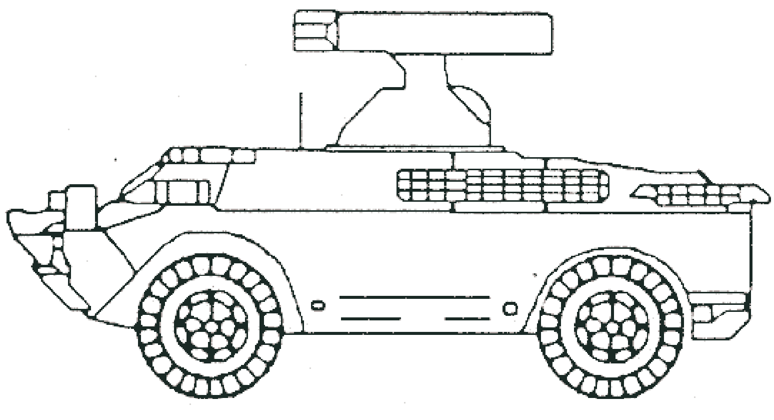
Crew: 5
Max road speed: 80 km/h
Max water speed: 8 km/h
Range (road): 500 km
Combat weight: 17500 kg
Length: 9.14 m
Width: 2.8 m
Height: 4.2 m
Ground clearance: 0.4 m
Armament: 6 SA-8 (9M33) missile
Launch weight: 126 kg
Warhead: 20 kg HE
Max speed: Mach 2,4
Engagement limits:
(target speed 1100 km/h)
Max range:10000 m
Min range: 1500 m
Max altitude: 5000 m
Min altitude: 25 m
(target speed 1800 km/h)
Max range:10000 m
Min range: 1500 m
Max altitude: 5000 m



# SA-9 "Strela-1"

***Type: Low-Altitude SAM***

Crew: 3
Configuration: 4x4
Engine: GAZ-41 V-8 140 hp
Max road speed: 100 km/h
Max water speed: 10 km/h
Fuel distance: 750 km
Combat weight: 7000 kg
Power-to-weight ratio: 20 hp/t
Length: 5.8 m
Width: 2.4 m
Height: 2.3 m
Ground clearance: 0.43 m
Armour: 5-14 mm
Armament: 4x 9M31(SA-9) missile
Traverse: 360°
Elevation: +20° to +80°
Tracking rate: 15-20°/s
Ammunition: 4+2 SA-9s
Launch weight: 32 kg
Warhead: 2.6 kg HE



## SA-10 "Strela-10"

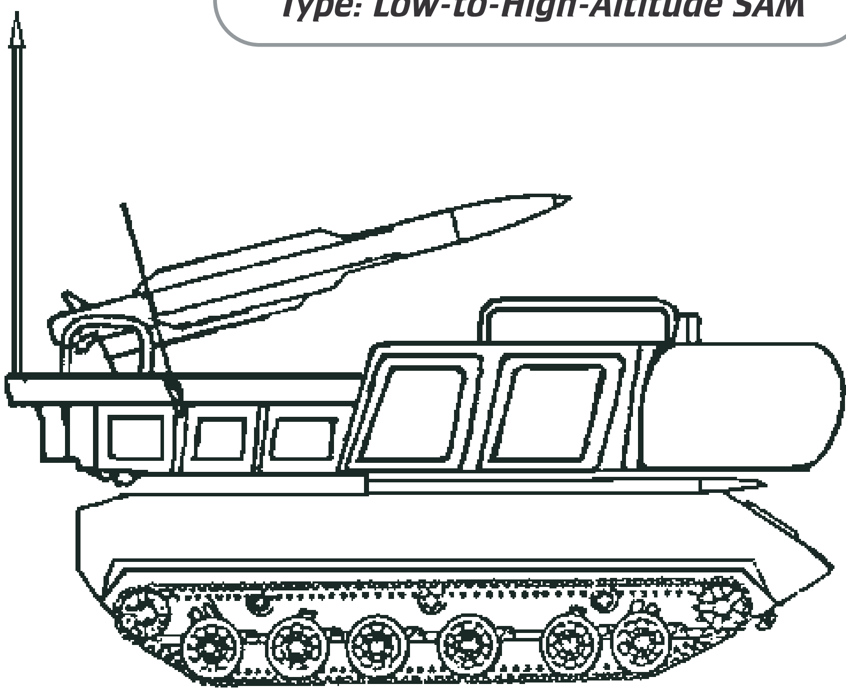
***Type: Low-to-High-Altitude SAM***

Crew: 3
Engine: YaMZ-238V diesel 240 hp
Max road speed: 61.5 km/h
Max water speed: 6 km/h
Fuel distance: 500 km
Combat weight: 12300 kg
Length: 6.6 m
Width: 2.85 m
Height: 3.8 m
Unit of fire: 8 missiles
Elevation/depression: +80°/-5°
Turret traverse: 360°
Tracking rates:
(elevation) 0.3-50°/s
(azimuth) 0.3-100°/s
Armament: 4x 9M333(SA-13) missiles
Launch weight: 42 kg
Warhead: 4 kg HE
Max speed: Mach 2
Max effective range: 5000 m
Min effective range: 200 m
Max effective altitude: 3500

## SA-11 "Buk"

***Type: Low-to-High-Altitude SAM***

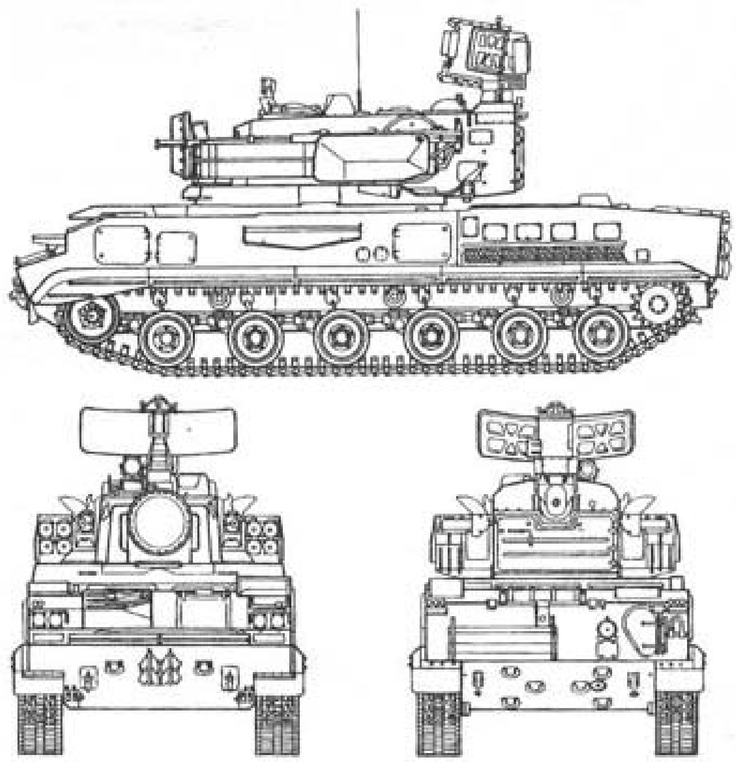
Self-propelled Mount
Max radar detection range:
(target at 3000 m altitude) 85 km
(target at 100 m altitude (MTI mode)) 35 km
(target at 30 m altitude (MTI mode and in crest angles of zero degrees)) 23km
Max radar lock on range:
(target at 3000 m altitude) 70 km
(target at 100 m altitude (MTI mode)) 30 km
(target at 30 m altitude (MTI mode)) 20 km
(hovering helicopter at 30 m altitude) 8-10 km
Min radar tracking range:
3000 m



# SA-19 “Tunguska"

***Type: Self-propelled Anti-Aircraft***

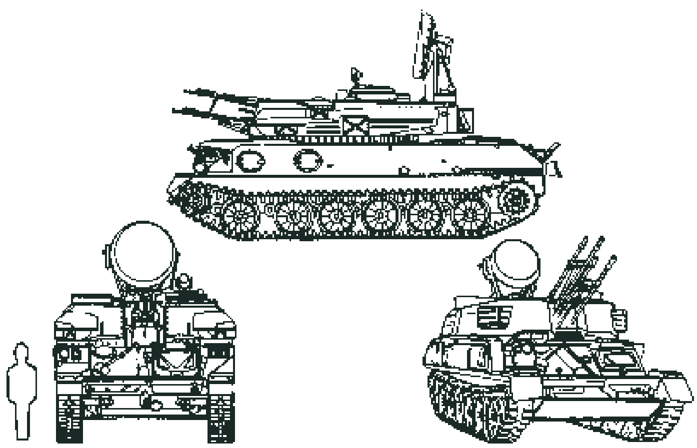
Crew: 4
Engine: V-64-4 V-12 diesel 740 hp
Max road speed: 65 km/h
Fuel distance: 500 km
Combat weight: 34000 kg
Length: 7.93 m
Width: 3.236 m
Height: 4.021 m
Armament:
2x30 mm 2A38M cannon
2x4 SA-19 SAM (9M311)
Ammunition:
(gun) 1,904
(missile) 8
Gun elevation/depression: +80°/-6°
Turret traverse: 360°
Launch weight: 165 kg
Warhead: 15 kg HE
Max speed: 850 m/s
Max effective range: 12000 m
Min effective range: 1500 m



# ZSU-23-4 "Shilka"

***Type: Self-propelled Anti-Aircraft***

Crew: 4
Engine: V-6R V-6 diesel 280 hp
Max road speed: 44 km/h
Fuel distance: 450 km
Combat weight: 20500 kg
Power-to-weight ratio: 20.0 hp/t
Length: 6.54 m
Width: 2.95 m
Height: 3.8 m
Ground clearance: 0.4 m
Armament:
4x23 mm AZP-23M cannon
Ammunition: 2000 rounds
Gun elevation/depression: +85°/-4°
Turret traverse: 360°
Max effective range: 2500 m



| Key | Action |
|---|---|
| | **PROGRAM CONTROL** |
| Esc | End mission/track |
| Ctrl-Q | Take control in the track |
| Shift-Backspace | Track edit Replace mode (disable old editing commands) |
| Alt-Backspace | Track edit Insert mode (don't disable old editing commands) |
| Ctrl-S | Toggle Sound On or Off |
| Ctrl-0 | Begin recording microphone sound in the track |
| Shift-0 | End recording microphone sound in the track |
| Alt-0 | Record On or Off the place of cursor in the track |
| Ctrl-9 | Begin recording subtitle in the track |
| Shift-9 | End recording subtitle in the track |
| Ctrl-A | Accelerate simulation speed |
| Alt-A | Decelerate simulation speed |
| Shift-A | Reset normal simulation speed |
| S | Toggle Pause/Resume/Launch model time at the mission start. |
| Ctrl-M | Chat feature for multi-player network games. |
| Shift-Return | Recover human plane in the network games. |
| Alt-J | Jump into selected AI plane cockpit or leave current plane cockpit. |
| Ctrl-Backspace | Show frame rate |
| Ctrl-O | Save a rollback point to the track (in pause mode) – not implemented |
| Alt-O | Return to the previous rollback point – not implemented |
| Shift-O | Jump to the next rollback point – not implemented |
| Print Screen | Upload screen shots to ScreenShots folder, numbering them with 0, 1, 2, … |
| | **FLIGHT CONTROL** |
| Down Arrow | Nose up |
| Up Arrow | Nose down |
| Left Arrow | Bank left |
| Right Arrow | Bank right |
| Ctrl-. *(Period)* | Trim up |
| Ctrl-; *(Semi-colon)* | Trim down |
| Ctrl-, *(Comma)* | Trim left |
| Ctrl-/ (*Slash)* | Trim right |
| Z | Rudder left (in flight), left turn (taxi) |
| X | Rudder right (in flight), right turn (taxi) |
| Ctrl-Z | Trim left rudder |
| Ctrl-X | Trim right rudder |
| H | Toggle altitude stabilization mode |
| Shift-M | Reset Current Audible Warning |
| Ctrl-L | Toggle on-board lights |
| Alt-V | Toggle immortality mode for own plane (doesn't work in network and in protected missions) |
| K | Execute "Pugachev's Cobra" |
| U | Setting your plane to the takeoff site on the carrier |
| Ctrl-T | Cancel Trim Settings |
| Alt-H | Radio request to AWACS for bearing and distance to the home airfield |
| Alt-T | Radio request to AWACS for bearing and distance to the tanker |
| Shift-+ *(Plus)* | Increase basic pressure of the Altimeter |
| Shift- - *(Minus)* | Decrease basic pressure of the Altimeter |
| Shift-P | Power switch |
| Alt-P | Automatic spin recovery (press to recover from spin state) |
| Alt-S | Speed retention toggle |

| | |
|---|---|
| Alt-E | Easy landings toggle |
| | |
| | **_THROTTLE CONTROL_** |
| J | Toggle auto-throttle |
| Page Up | Increase Throttle in increments |
| Page Down | Decrease Throttle in increments |
| Key Pad + *(Plus)* | Increase Throttle smoothly |
| Key Pad - *(Minus)* | Decrease Throttle smoothly |
| Page Up | Engine Start |
| Page Down | Engine Stop |
| Change of throttle according to engine | |
| With Alt | Left engine only |
| With Shift | Right engine only |
| | |
| | **_MECHANICAL SYSTEMS CONTROL_** |
| B | Toggle airbrake |
| Shift-B | Airbrake out |
| Ctrl-B | Airbrake in |
| Ctrl-E | Eject |
| E | Toggle active jamming (requires ECM pods in loadout) |
| F | Toggle flaps up/down |
| Shift-F | Flaps down to the landing position |
| Ctrl-F | Flaps up |
| G | Toggle landing gear up/down |
| Ctrl-G | Toggle arrestor hook down or up *(Note: Su-33 only)* |
| Ctrl-C | Canopy open/close |
| P | Release drogue chute |
| Ctrl-P | Toggle folding wings *(Note: Su-33 only)* |
| Ctrl-R | Dump fuel (in flight) or refuel (ground) *(Note: Hold down key)* |
| Alt-R | Jettison fuel tanks |
| W | Engage wheel brakes (ground) *(Note: Hold down key)* |
| T | Toggle wingtip smoke |
| R | Toggle refueling boom |
| Alt-L | Toggle gear light Near/Far/Off |

| | |
|---|---|
| | **_NAVIGATION_** |
| ~ *(Tilde)* | Select next waypoint or airfield |
| A | Toggle auto-pilot. If the autopilot is on then the plane tries to fly along the route in the NAV mode or to take the horizontal position in combat modes. |
| 1 | Toggle to set Navigation (NAV) modes |
| Alt-C | Reset flight clock |

| | |
|---|---|
| | **_COMBAT MODES_** |
| 2 | Toggle to set Beyond Visual Range (BVR/DVB) mode |
| 3 | Select Close Air Combat – Vertical Scan (CAC/BVB – VS) mode |
| 4 | Select Close Air Combat – Bore (CAC/BVB – BORE/STR) mode |
| 5 | Select Close Air Combat – Helmet-Mounted Target Designator (CAC/BVB – HMTD/SHLEM) mode |
| 6 | Select Longitudinal Missile Aiming (LNGT/FIO) mode |
| 7 | Select Air-to-ground (GND/ZEMLYA) mode |
| 8 | Select Grid (SETKA) mode |
| ~ *(Tilde)* | Cycle through targets (Cycle through targets on MFD in AWACS and Ground Attack Modes) |
| TAB | Lock selected target (Turn on tracked target) |
| Ctrl-TAB | Turn off tracked target |

| | |
|---|---|
| TAB | Lock target |
| TAB | Turn on/off tracked target in Close Air Combat modes |
| Ctrl-H | Cycle through Heads Up Display (HUD) intensities |
| | |
| | ***WEAPONS*** |
| D | Cycle through weapons selection |
| C | Toggle cannon |
| Q | Dispense chaff & flare |
| Shift-Q | Continuously dispense chaff & flares (until supply is exhausted) |
| Spacebar | Fire current weapon |
| Ctrl-W | Jettison weapons (in pairs) while airborne, reloads weapons while on the ground |
| Ctrl-V | Toggle Salvo mode on or off |
| Shift-C | Change rate of fire for the gun of A-10 |
| V | Increase the ripple interval for A-10 |
| Shift-V | Decrease the ripple interval for A-10 |
| Ctrl-Space | Change the ripple quantity for A-10 |
| Alt-Space | Switch the master arm for A-10 |
| Shift-Space | Change the release mode for A-10 |
| Shift-R | Change the RWR mode for A10 |
| | |
| | ***RADAR & ELECTRO-OPTICAL SYSTEMS*** |
| I | Toggle radar illumination on or off |
| Shift-I | Easy radar mode toggle |
| Alt-I | Switch between RWS/TWS modes for F-15 radar |
| O | Toggle Electro-Optical System (EOS) on or off |
| Ctrl-I | Center radar antenna/Infra-Red Scan and Track(ISRT) ball |
| - *(Minus)* | Multi-Functional Display (MFD) zoom in |
| + *(Plus)* | Multi-Functional Display zoom out |
| Ctrl-+ | Increase radar antenna azimuth limit for F-15 radar |
| Ctrl-- | Decrease radar antenna azimuth limit for F-15 radar |
| | |
| | ***AUTO LOCK ON*** |
| ScrollLock | Lock on to nearest enemy air target |
| Alt-ScrollLock | Lock on to enemy air target nearest the center of the player's view |
| Shift-Insert | Lock on to previous enemy air target |
| Shift-NumLock | Lock on to next enemy air target |
| Shift-ScrollLock | Lock on to nearest enemy ground target |
| Control-ScrollLock | Lock on to enemy ground target nearest the center of the player's view |
| Shift-Delete | Lock on to previous enemy ground target |
| Ctrl-NumLock | Lock on to next enemy ground target |
| | |
| | ***BEYOND VISUAL RANGE MODE*** |
| Shift-; *(Semicolon)* | Move radar/EOS scan zone UP |
| Shift-, *(Comma)* | Move radar/EOS scan zone LEFT |
| Shift-. (Period) | Move radar/EOS scan zone DOWN |
| Shift-/ *(Slash)* | Move radar/EOS scan zone RIGHT |
| -; *(Semicolon)* | Move HUD target designator Box DOWN (BVR only) |
| -, *(Comma)* | Move HUD target designator Box LEFT (BVR only) |
| -. (Period) | Move HUD target designator Box UP (BVR only) |
| -/ *(Slash)* | Move HUD target designator Box RIGHT (BVR only) |
| | |
| | ***CLOSE AIR COMBAT MODE*** |
| Shift-; *(Semicolon)* | Move radar/EOS scan zone UP |
| Shift-, *(Comma)* | Move radar/EOS scan zone LEFT |

| | |
|---|---|
| Shift-. (Period) | Move radar/EOS scan zone DOWN |
| Shift-/ *(Slash)* | Move radar/EOS scan zone RIGHT |

## *GROUND MODE*

| | |
|---|---|
| Shift-; *(Semicolon)* | Move radar/TV seeker scan zone UP |
| Shift-, *(Comma)* | Move radar/TV seeker scan zone LEFT |
| Shift-. (Period) | Move radar/TV seeker scan zone DOWN |
| Shift-/ *(Slash)* | Move radar/TV seeker scan zone RIGHT |

## *WINGMAN COMMANDS*

| | |
|---|---|
| Del | Dispatch wingman on mission. On mission completion, join up |
| Ins | Toggle tight formation or loose formation |
| [ | Attack my target |
| ] | Cover my six o'clock (rear) position |
| \ | Call wingman commands dialog |

## *VIEW SELECTION*

| | |
|---|---|
| F1 | Cockpit View |
| Ctrl-F1 | Natural Head Movement View |
| Alt-F1 | HUD Only View |
| F2 | External View – All Aircraft & Parachutist |
| Shift-F2 | Aircraft labels toggle |
| F3 | Fly-By View |
| Ctrl-F3 | Fly-By Jump View (saving current camera position) |
| F4 | Chase View |
| F5 | Air Combat View (Cycles through locked enemy planes around the current plane from nearest to farthest. Looks at the enemy plane from the current plane and shows enemy data in the info string. Refreshes locking at every switch.) |
| Ctrl-F5 | Air to Ground Combat View (Cycles through locked enemy vehicles/ships around the current plane from nearest to farthest. Looks at the enemy vehicle/ship from the current plane and shows enemy data in the info string. Refreshes locking at every switch.) |
| F6 | Weapons View |
| Ctrl-F6 | Chase Weapon View ("Weapon To Target" View) |
| Shift-F6 | Launched missiles labels toggle |
| F7 | Active Ground Objects View |
| F8 | Target View |
| F9 | Ship View |
| Alt-F9 | Landing Signal Officer (LSO) View |
| Shift-F9 | Ships and ground units labels toggle |
| F10 | Theater View |
| Shift-F10 | Object labels toggle |
| F11 | Tower & Terrain View |
| Ctrl-F11 | Switches to Tower & Terrain View saving current view position (freezing camera position). When switching from Theater View (F10) the current F11 camera position comes from the F10 camera position, but it's altitude does not exceed 20km. |
| F12 | Static Objects View |
| Ctrl-F12 | Civilian transport |
| Shift-F11 | Trains/cars toggle for Ctrl-F12 view |
| Ctrl - Keypad 1-9 | Cockpit camera discrete steps |

## *VIEW MODIFIERS*

| | |
|---|---|
| Ctrl-Home | Places external views to Friendly only |
| Ctrl-End | Places external views to Enemy only |
| Ctrl-Delete | Places external views to All |

| | |
|---|---|
| Keypad Del | Toggle Padlock View (Note: for F1, F2, F6, F7, F8, F9, Alt-F9 LSO View & F11 Tower View only) |
| Ctrl-Keypad Del | Toggle Terrain Point Padlock View (Note: for F2, F6, F7, F8, F9 Views only) |
| Backspace | Toggle "From object/To object" camera direction mode (Note: for F2, F6, F7, F8, F9, F12 Views only) |
| Alt-Delete | Exclude current object from the view switching |
| Alt-Insert | Include all excluded objects to the view switching |
| Ctrl-PageUp | Reverse objects switching direction |
| Ctrl-PageDown | Forward objects switching direction |
| | |
| Ctrl Key Pad +(plus) | Switch to Weapons Release and Track View for F1 Cockpit, F2 External, F4 Chase, F7 Active Ground Targets, and F9 Ship Views. Switches to ANY weapon now, not to bombs & missiles only! |
| Alt-Key Pad * | Starts moving camera forward (F11Tower & Terrain View only) |
| Alt-Key Pad / | Starts moving camera backward (F11Tower & Terrain View only) |
| Key Pad 5 | Stops moving camera (F11 Tower & Terrain View) |
| Alt-Key Pad 5 | Returns to Tower & Terrain View starting point |
| Y | External View Information Display Cycle Toggle |
| Alt-Y | Earth Coordinates Units Toggle (Degrees/Meters) |
| Alt-Backspace | Insert video edit mode toggle (replace mode is on by default) |
| Shift-Backspace | Replace video edit mode toggle (default) |
| Shift-J | External camera jiggle toggle |
| Shift-Esc | Toggle local/object camera rotation mode for F2, F4, F6, F7, F8, F9 and F12 views. |

| | ***COCKPIT VIEW CONTROL*** |
|---|---|
| Key Pad 1 | Move head down and left |
| Key Pad 2 | Move head down |
| Key Pad 3 | Move head down and right |
| Key Pad 4 | Move head left |
| Key Pad 5 | Centers camera |
| Key Pad 6 | Move head right |
| Key Pad 7 | Move head up and left |
| Key Pad 8 | Move head up |
| Key Pad 9 | Move head up and right |
| Shift – Key Pad 1-9 | Move head quickly |
| Ctrl – Key Pad 1-9 | Move head with discrete steps |
| Alt – Z | Discrete steps mode toggle (to return or not to return camera tacitly) |
| Key Pad Del | Enable/disable padlock view |
| Shift-Key Pad Del | All missile padlock toggle |
| Alt-Key Pad Del | Threat missile padlock toggle |
| Ctrl Key Pad +(plus) | Switch to Weapons Release and Track View for F1 Cockpit, F2 External, F4 Chase, F7 Active Ground Targets, and F9 Ship Views. Switches to ANY weapon now, not to bombs & missiles only! |
| | |
| L | Toggle Cockpit Illumination |
| M | Move head to view right mirror |
| N | Move head to view right mirror |
| Key Pad * (Asterisk) | Zoom in (narrow view angle). With Shift – Zoom in to limit |
| Key Pad / (Divide) | Zoom out (enlarge view angle). With Shift – Zoom out to limit |
| Key Pad Enter | Set default zoom (default view angle). |
| Key Pad 0 | Jump to cockpit panel snap view and back (Note: Hold down then release) |

| | |
|---|---|
| | Hold down Key Pad 0 and press Key Pad 1-9 to jump around different instruments with close-up view. |
| Ctrl - Key Pad 0 | Cockpit panel snap view mode toggle. Don't hold down. Then press Key Pad 1-9 to jump around different instruments with close-up view. Press Ctrl - Key Pad 0 once more to return to normal mode. |
| Alt - Key Pad 0 | Save current camera position for the last cockpit snap view, corresponding to Key Pad 0 - 9. May be different for different planes! All new custom camera snap positions will be saved in the mission_file_name.xml file and then will always be used for that mission/track in future. Note: that feature is disabled by default. To enable it set parameter DisableSnapViewsSaving = 0 in the Config/View/View.cfg file. To use your custom views by default simply rename mission_file_name.xml to the Config/View/LookJump.xml. |
| Ctrl – Right Shift | Fast cockpit mouse speed |
| Alt – Right Shift | Slow cockpit mouse speed |
| Shift – Right Shift | Normal cockpit mouse speed |
| Ctrl – Left Shift | Fast cockpit keyboard speed |
| Alt – Left Shift | Slow cockpit keyboard speed |
| Shift – Left Shift | Normal cockpit keyboard speed |

## EXTERNAL VIEW CONTROL

| | |
|---|---|
| Key Pad 1 | Rotate viewpoint down and left |
| Key Pad 2 | Rotate viewpoint down |
| Key Pad 3 | Rotate viewpoint down and right |
| Key Pad 4 | Rotate viewpoint left |
| Key Pad 5 | Centers view (stops F11 viewpoint moving) |
| Alt-Key Pad 5 | Returns to starting point (F11 Tower & Terrain View only) |
| Key Pad 6 | Rotate viewpoint right |
| Key Pad 7 | Rotate viewpoint up and left |
| Key Pad 8 | Rotate viewpoint up |
| Key Pad 9 | Rotate viewpoint up and right |
| Key Pad * (Asterisk) | Move viewpoint forward |
| Key Pad / (Slash) | Move viewpoint back |
| Ctrl-Key Pad * (Asterisk) | Zoom in (narrow view angle). |
| Ctrl-Key Pad / (Divide) | Zoom out (enlarge view angle). |
| Ctrl-Key Pad Enter | Set default zoom (default view angle). |
| Shift-(all view keys) | Moves viewpoints at a faster rate (Note: Hold down Shift and view key) |
| Ctrl-(Key Pad 1-9) | Moves camera instead of rotate it. |

## MISSION EDITOR

| | |
|---|---|
| **File** | |
| Ctrl-N | Create new mission file |
| Ctrl-O | Open mission file |
| Alt-M | Merge mission file |
| Ctrl-S | Save mission file |
| Ctrl-Shift-S | Save As mission file |
| Alt-X | Exit Mission Editor and return to Main Menu |
| **Edit** | |
| Del | Delete selected object |
| Ctrl-Shift-C | Classify mission |
| Ctrl-Shift-D | Declassify mission |

| | |
|---|---|
| **View** | |
| Ctrl-H | Hide selected object |
| Ctrl-A | Actual size view (Crimean view) |
| Ctrl-+ | Zoom in |
| Ctrl-- | Zoom out |
| **Flight** | |
| Ctrl-B | Display Briefing |
| Ctrl-D | Display Debriefing |
| Ctrl-F | Start mission |
| Ctrl-R | Record track file |
| Ctrl-P | Play track |
| Ctrl-E | Video edit |
| Ctrl-L | Network Play |
| Ctrl-M | Chat in Network Play |
| **Customize** | |
| Ctrl-Shift-F | Failures |
| Ctrl-Shift-W | Weather |
| Ctrl-Shift-E | Encyclopedia |
| Ctrl-Shift-O | Options |
| Alt-Z | Remove all objects from Victory Condition of mission or campaign stage |

# Acronyms

## A

| | |
|---|---|
| AACQ | Auto Acquisition |
| ACP | Armament Control Panel |
| AGM | Air to Ground Missile |
| ADI | Attitude Direction Indicator |
| AIM | Air Intercept Missile |
| AMRAAM | Advanced Medium Range Air to Air Missile |
| AOA | Angle of Attack |
| API | Armour Piercing Incendiary |
| A-POLE | Shooter to target distance when missile goes active |
| ARH | Active Radar Homing |
| ASE | Allowable Steering Error |
| ASI | Airspeed indicator |
| AWACS | Airborne Warning and Control System |

*B*

| | |
|---|---|
| BFM | Basic Fighter Maneuvers |
| BVR | Beyond Visual Range |

*C*

| | |
|---|---|
| CAC | Close Air Combat |
| CCIP | Continuously Computed Impact point |
| CDI | Course Deviation Indicator |
| CRT | Cathode Ray Tube |

*D*

| | |
|---|---|
| DLZ | Dynamic Launch Zone |

*E*

| | |
|---|---|
| EGT | Exhaust Gas Temperature |
| EOS | Electro-Optical System |
| EWR | Early Warning Radar |

*F*

| | |
|---|---|
| FAF | Final Approach Fix |
| FOR | Field Of Regard |
| FOV | Field Of View |
| FPM | Flight Path Marker |
| F-POLE | Shooter to target distance at missile impact |
| FTIT | Fan Turbine Inlet Temperature |

*G*

| | |
|---|---|
| GCI | Ground Controlled Intercept |

*H*

| | |
|---|---|
| HEI | High Explosive Incendiary |
| HOJ | Home On Jam |
| HSI | Horizontal Situation Indicator |
| HUD | Head Up Display |

*I*

| | |
|---|---|
| IAF | Initial Approach Fix |

| | |
|---|---|
| ILS | Instrument Landing System |
| IRST | Infrared Search and Track |
| *L* | |
| LCOS | Lead Computing Optical Sight |
| LMA | Longitudinal Missile Aiming |
| *M* | |
| MFD | Multifunction Display |
| MPCD | Multi Purpose Color Display |
| *N* | |
| N1 | Turbofan speed |
| N2 | Engine gas generator(core) speed |
| NAV | Navigation |
| NCTR | Non Co-operative Target Recognition |
| *P* | |
| PDT | Primary Designated Target |
| PRF | Pulse Repetition Frequency |
| PRS | Pairs |
| *R* | |
| RIP | Ripple |
| RPM | Revolutions Per Minute |
| RMAX | Maximum Range |
| RMIN | Minimum Range |
| RPI | Maximum range against a non-maneuvering target |
| RTR | Maximum range against a maneuvering target |
| RWR | Radar Warning Receiver |
| RWS | Range While Search |
| *S* | |
| SARH | Semi-Active Radar Homing |
| SDT | Secondary Designated Target |
| SGL | Single |
| SRM | Short Range Missile |
| STT | Single Target Track |
| *T* | |
| TD | Target Designation |
| TDC | Target Designation Cursor |
| TEWS | Tactical Electronic Warfare System |
| TTA | Time To Active |
| TTI | Time To Intercept |
| TVM | Television Monitor |
| TVV | Total Velocity Vector |
| TWS | Track While Scan |
| *V* | |
| VVI | Vertical Velocity Indicator |
| VSD | Vertical Situation Display |
| VSI | Vertical Speed Indicator |
| VV | Velocity Vector |
| *W* | |
| WVR | Within Visual Range |

# Brevity Code

**ABORT:** Directive commentary to terminate. Applicable to a specific attack maneuver or entire mission.

**ACTIVE:** An onboard radar self-guidance mode of an advanced AAR like the AIM-120 AMRAAM

**ALPHA CHECK:** A request for bearing and distance to a given point. Generally used to confirm navigational accuracy

**ANCHOR:** 1 - Begin an orbit at a specific point or location. 2 - A refueling track flown by a tanker aircraft.

**ANGELS:** Altitude expressed in thousands of feet. Angels 20 means 20,000 feet.

**ARIZONA:** No anti-radar weapons remaining.

**AS FRAGGED:** Perform the event as briefed or planned.

**BANDIT:** Known enemy aircraft. Only used when the contact is confirmed hostile.

**BEAM/BEAMER:** Descriptive terminology for an aircraft that maneuvered to stabilize between 70 degrees 110 degrees aspect. Can be used to describe your own action.

**BELLY CHECK:** Directive commentary to instruct recipient to roll over and check for bandits underneath him.

**BENT:** Inoperative

**BINGO FUEL:** A predetermined fuel quantity that is required to safely return to base.

**BLIND:** Lost visual contact with appropriate friendly aircraft. Generally means that the wingman lost sight of a flight lead. The opposite of this is VISUAL.

**BOGEY:** An unknown radar or visual contact.

**BOGEY DOPE:** A request for information about a specific target or threat. Generally directed toward GCI/AWACS or other flight members.

**BOX:** Groups/contacts/formations in a square, as viewed on a radar display or from above.

**BRACKET:** Indicates geometry where aircraft will maneuver to a position on opposing sides of a given point / target, either laterally / vertically/ or a combination of both. Basically, it is a relatively short-range *pincer* maneuver.

**BREAK:** (Up/Down/Right/Left) –Directive to perform an immediate *maximum performance* turn. Assumes a defensive situation that requires immediate action.

**BREVITY:** Denotes radio frequency is becoming saturated/degraded/jammed and more concise/less R/T transmissions should be used.

**BUDDY SPIKE:** Illumination by friendly air to air radar.

**BUG OUT:** Separate from the engagement and head for a safe area or home.

**BULLSEYE:** A pre-briefed reference point. It is used to describe your position or that of the target.

**CLEAN:** 1 - No radar contacts. 2 - An aircraft configuration without any external stores or tanks.

**CLEARED:** Requested action is approved.

**CLEARED HOT:** Ordnance release is approved.

**CLOSING:** Bandit/bogey/target is decreasing its range.

**COLD:** 1 - Attack geometry that will result in a position behind the target. (lag pursuit) 2 - Pointed away from the anticipated threats.

**COMMITTED/COMMIT:** Intent to engage/intercept.

**CONTACT:** Radar/IR contact; should include bearing, range, altitude (BRA), Bull's-eye, or geographic position information.

**CONTINUE:** Continue present maneuver; does not imply clearance to engage or to shoot.

**COVER:** Directive to assume supporting role and responsibilities.

**DEFENSIVE:** (Spike/Missile/SAM/Mud/AAA) – Subject is in a defensive position and maneuvering with reference to the threat.

**DRAG/DRAGGING:** (Direction) – Bogey/Bandit maneuvering to 60 degrees or less aspect. Can also describe your own actions.

**ENGAGED:** Maneuvering with respect to a threat or target in order to kill or negate an attack.

**EXTEND:** (Direction) – Directive to temporally depart the immediate 'fight' location gain energy, distance, time, situational awareness, or a combination of all.

**FADED:** Radar contact is lost or has 'faded' from your radar display.

**FEET WET/DRY:** Transitioning from flying over water/land.

**FENCE CHECK/FENCE IN/FENCE OUT:** Set cockpit switches as appropriate to your location. Generally means to arm up weapons as you enter enemy territory and safe them as you proceed back to friendly airspace.

**FLANK/FLANKING:** Target with a stable aspect of 120 degrees to 150 degrees.

**FLOAT:** Expand the formation laterally within visual limits. Used to initiate a 'bracket' or to force a commit from a trailing bandit.

**FOX ONE:** Simulated/actual launch of semi-active radar guided missile like an AIM-7 Sparrow.

**FOX TWO:** Simulated/actual launch of an IR guided missile like an AIM-9 Sidewinder.

**FOX THREE:** Simulated/actual launch of a fully active missile like an AIM-120 AMRAAM.

**GADGET:** Radar or sensor equipment.

**GIMBALL:** (Direction) – Radar target of interest is approaching azimuth or elevation limits of your radar and you are about to loose contact.

**GORILLA:** A large number of unknown contacts that appear to maneuver to a common objective.

**GROUP:** Radar Contacts that appear to operate together within approximately 3 nm of each other.

**HARD LEFT/RIGHT:** Directive call to initiate a High-G, energy sustaining turn. Generally used when entering a fight offensively. A 'break' turn is used for a defensive situation.

**HIGH:** Target altitude at or above 30,000 feet MSL.

**HIT:** A radar return on the radar display.

**HOLDING HANDS:** Aircraft together in a coordinated visual formation.

**HOME PLATE:** Home airfield.

**HOT:** 1 - For an AI intercept 'hot' describes geometry will result in roll out in front of target. 2 - Pointing toward the anticipated threats in a CAP. 3 - Weapons employment authorized.

**IN PLACE:** (Left/Right) – Simultaneously maneuvering the whole flight in the specified direction.

**JOKER:** Has had several definitions 1.) Fuel state is such that the mission can continue to the target via planned route and RTB, but with little or no reserve.

**KILL:** Commit and kill specified target.

**LADDER:** Three or more groups in trail formations. It appears as a 'ladder' on the radar display

**LINE ABREAST:** A side-by-side formation.

**LOCKED:** (BRA/Direction) – Radar Lock on.

**LOW:** Target altitude below 10,000 feet MSL

**MAGNUM:** Launch of an air to surface anti-radar missile.

**MEDIUM:** Target altitude between 10,000 and 30,00 feet MSL.

**MERGE/ MERGED:** 1 - Bandits and friendlies are in the visual arena. 2 - Radar returns have come together.

**MUSIC:** Electronic radar jamming.

**NO JOY:** Lost or no visual contact with the target/bandit; opposite of TALLY.

**NOTCH:** (Direction) – Radar missile defensive maneuver to place threat radar/missile near the beam.

**PADLOCKED:** Aircrew cannot take eyes off target without risk of losing tally/visual.

**PAINT:** Illuminate an object with radar energy.

**PICTURE:** Situation briefing given by AWACS or GCI that provides a general tactical overview.

**PITBULL:** AIM-120 AMRAAM is at active range.

**POSIT:** Request for a position report.

**PRESS:** Continue the attack; mutual support will be maintained.

**PUSHING:** Departing designated point.

**RIFLE:** Launch of an air to air tactical missile.

**SEPARATE:** Leaving a specific engagement.

**SHACKLE:** A weave or a single crossing of flight paths in order to regain geometry.

**SHOOTER:** Aircraft that will employ ordnance or 'shoot'

**SLOW:** speed of less than 300 knots.

**SNAP:** (object, destination, location.) – An immediate vector to the requested target or geographic point.

**SORTED:** Pre-briefed criteria has been met insuring each flight member have separate targets.

**SPIKE:** RWR indication of an emitting radar.

**SPITTER:** (Direction) – An Aircraft that has departed from the engagement.

**STACK:** Two or more groups with a high/low altitude separation.

**STATUS:** Request for an individual's tactical situation; generally described as 'offensive,' 'defensive,' or 'neutral.'

**STINGER:** Formation with single Bogey/Bandit in trail.

**SWITCH/SWITCHED:** Indicates an attacker is changing from one aircraft to another.

**TALLY:** Bandit in sight; opposite of 'NO JOY'.

**TARGET:** Specific sort responsibility

**TRAIL:** Formation of two or more aircraft following one another.

**TRAILER:** The last aircraft in a formation.

**TRASHED:** Missile in flight has been defeated.

**TUMBLEWEED:** Indicates limited situation awareness, no tally, no visual, a request for information.

**VEE/VIC:** Vic formation, single aircraft in the lead and an element in trail.

**VISUAL:** Friendly aircraft in sight; opposite of 'BLIND'.

**WALL:** Three or more groups in line abreast/side-by-side formation.

**WEDGE:** Tactical formation of two or more aircraft with the single in front and two line abreast behind: Same as a 'Vee' formation.

**WEEDS:** Very low altitude.

**WINCHESTER:** No ordnance remaining

# *Lock On: Modern Air Combat SAM/AAA Reference Sheet*

## *Russian Air Defence Combat Units*

### S-300PS Low/High Altitude Long Range SAM – NATO ID: SA-10 Grumble

S-300PS 54K6-CP Command Post Truck Unit
S-300PS 40B6MD-SR Tower mounted aerial surveillance radar - **Clam Shell – 65 nm range**
S-300PS 40B6M-TR Tower mounted aerial guidance radar – **Flap Lid**
S-300PS 64H6E-SR Truck mounted aerial surveillance radar - **Big Bird – 162 nm range**
S-300PS 5P85C-LN 4 tube truck mounted launcher –- **25 nm range**
S-300PS 5P85D-LN 4 tube truck mounted launcher –- **25 nm range**

### Buk Low/High Altitude Medium Range SAM – NATO ID: SA-11 Gadfly

Buk 9S470M1-CP Track mounted command post
Buk 9S18M1-SR Track mounted surveillance radar – **Snow Drift – 46 nm range**
BuK 9A310M1-LN 4 missile track mounted launcher – **17 nm range**
Buk9A39M1-LD/LN 4 missile track mounted loader/launcher – **1.5 to 17 nm range**

### Kub Low/Medium Altitude Medium Range SAM – NATO ID: SA-6 Gainful

Kub 1S91-STR Track mounted surveillance/guidance radar – **Straight Flush – 40 nm range**
Kub 2P25-LN 3 missile track mounted launcher – **2 to 13 nm range**

### Osa Low Altitude Short Range SAM – NATO ID: SA-8 Gecko

Osa 9A33-LN Amphibious 6 missile radar guided SAM – **1 to 5 nm range**
Osa 9T217-LD Amphibious missile reload vehicle

### Strela Low Altitude Short Range SAM – NATO ID: SA-13/SA-9

Strela-10 9A35 4 missile track mounted infrared guided SAM - **SA-13 Gopher – 3 nm range**
Strela-1 9P31 4 missile amphibious infrared guided SAM - **SA-9 Gopher – 2 nm range**

### Dog Ear Radar Low Altitude Short Range Radar – NATO ID: SA-13/SA-9 – 43 nm range

### Tor Low/Medium Altitude Short Range SAM – NATO ID: SA-15 Gauntlet

Tor 9A331 8 missile track mounted radar guided SAM – **6.5 nm range**

### Tunguska Low Altitude Short Range SAM/AAA Unit – NATO ID: SA-9 Grisom

Tunguska 2C6M 8 missile track mounted radar directed AAA/SAM – **6.5 nm range**

### Shilka Low Altitude Short Range AAA Unit – NATO ID: Zeus

Shilka ZSU-23-4 4 x 23mm radar directed AAA – **1.3 nm range**

### Igla Low Altitude Short Range MANPAD – NATO ID: SA-16 Gimlet

Igla-1 9K310 Man Portable infrared guided SAM – **1.6 nm range**

## NATO Air Defence Combat Units

### Patriot Medium/High Altitude, Long Range SAM

| | |
|---|---|
| Patriot-CP | Engagement control station |
| Patriot-STR | Trailer mounted acquisition/guidance radar – **170 km range** |
| Patriot-LN | 4 tube trailer mounted launcher – **3 to160 km range** |

### Hawk Low/Medium Altitude, Medium Range SAM

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|---|---|
| Hawk-SR | Trailer mounted acquisition radar |
| Hawk-TR | Trailer mounted guidance radar |
| Hawk-LN | 3 missile trailer mounted launcher – **2 to 32 km max range** |

### Roland ADS Low Altitude, Short Range SAM

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|---|---|
| Roland ADS | Track mounted radar guided SAM unit - **1/2 to 6.3 km range** |
| Roland Radar | Track mounted aerial acquisition radar - **30 km range** |

### Vulcan Low Altitude, Short Range AAA

| | |
|---|---|
| Vulcan | Track mounted radar guided 6 barrel 20mm AAA – **2.6 km range** |

### Avenger Low Altitude, Short Range SAM

| | |
|---|---|
| Avenger | 8 missile truck mounted Infrared guided SAM unit – **7 km range** |

### Gepard Low Altitude, Short Range AAA

| | |
|---|---|
| Gepard | Track mounted radar guided twin 35mm AAA unit – **3 km range** |

### Stinger Low Altitude, Short Range MANPAD

| | |
|---|---|
| Stinger | Man portable Infrared guided SAM – **4 km range** |