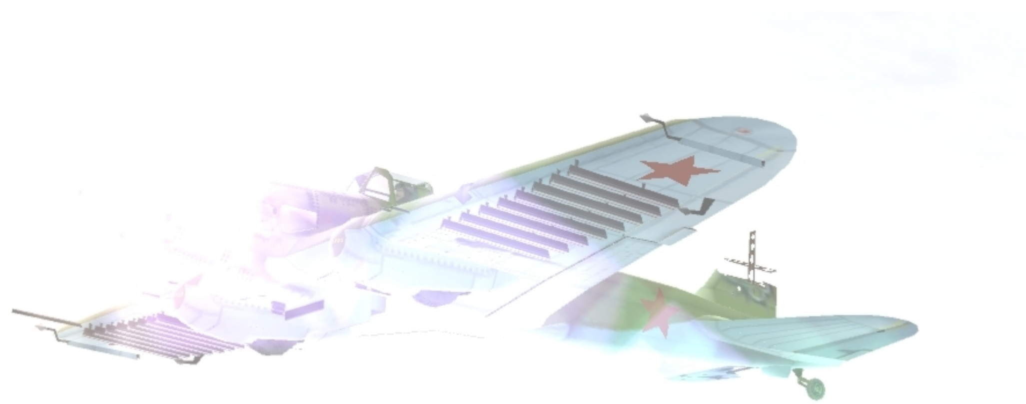
Note: This initial version of the document is full of incomplete sections, oversights, omitted credit, incomplete sentences, etc. It has been placed online for peer review and because it has been deemed useful to some degree as is. It is kindly requested that you do not redistribute this document to others, but provide them with a link to the homepage. (You will find this link on the title page.) This will help prevent confusion with forthcoming versions, and give me a chance to correct some of the major errors in upcoming weeks. Please consider this work in its current stage as something analogous to the alpha release of a software package. Peer reviews are appreciated. Thanks very much. – Mike, July 11, 2003



A User's Guide to

IL-2 Sturmovik

hosted at Eastern Skies
http://people.ee.ethz.ch/ chapman/il2guide/

Version 0.1
July 11, 2003

This work is dedicated to all the men and women who served their countries and fellow man on land, sea and in the air in the Great Patriotic War, the Second World War.

Preface

You probably do not want to sit down and read this guide from the beginning. It is a fairly long read, although some of the material, and especially the instructive material, is meant to be read progressively. Other parts might be browsed through and read selectively. It is up to you, the reader, to know which parts you believe you will find useful and which parts not. Feel free to skip around, but keep in mind that with some effort you might learn something useful.

A lot of this manual was written with a joystick on the desk. Its main reference is *IL-2* itself; beyond stemming from user experience, a lot of checking was done to make sure this and that were correct and really so in the simulator. Another important source of the material in this book was the *IL-2* community, notably those at the Ubi *IL-2 Sturmovik* forums, especially in General Discussion and Technical Support. Every effort is being made to give credit to the contributors, even if all sources are not yet listed. If you think you have found an area where credit is not given, please contact the editor through the website.

Editor's Notes

You won't get very far without noticing that this is a work in progress. The guide has been written out of love for the game and the hope of helping others, thereby bringing the *IL-2* community closer together, but the process of putting it together has occurred over an extended period during free time, and it has not been through a rigorous editing process. There are bound to be inconsistencies, errors and omissions. All that is asked of you beyond your understanding is that you not turn a blind eye. Submit suspected mistakes (besides areas where the work is blatantly incomplete) by dropping an email at the official site. You might even consider sharing some of your knowledge by contributing.

The document was prepared with the LaTeX 2_ε system, and it was used to embed hyperlinks directly into the PDF. You should be able to click them to navigate about the document, and many links take you directly to a linked website through your browser if this feature is supported on your computer. This is meant to be a feature and not a bug, but hasn't been well tested. In particular the original method of online citation, which involved linking to URLs in the bibliography, persists in several places, as time has not yet permitted to update. Note that, in addition to a linked table of contents, in Adobe®Acrobat Reader®, the bookmark feature allows you to always have a window frame open for easy navigation.

The current page format is A4, the European standard for "normal" printing, although the page layout is conservative and can be printed on Letter format. The headers and margins are also double-sided for printing, which is why some pages are left blank. In future versions the document should be made available in various formats, including both A4 and letter format for both double- and single-sided layouts, plus an "e-book" version.

Another planned feature is the implementation of tracks for the demonstration of principles and techniques throughout relevant sections. This can become extremely time consuming for a single person, and readers and of course experienced pilots are enthusiastically requested to submit tracks to this purpose.

The inclusion of graphics makes the document far more attractive to the eye, but this being an Internet document it is a difficult call to what extent they ought to be included. Some illustrations are already included, and more are likely to appear, but the document should not become prohibitively large. One possible solution is to make a version of the document that leaves large graphics out and places a hyperlink that leads to an online version of the graphic. This has the advantage of leaving the choice of downloading graphics to the user.

The manual may eventually be converted to a HTML format. However, this depends on its success and the ratio of amount of work involved to the amount of available help.

CONTENTS

CHAPTER 1

Introduction

Be sure.

— Oleg Maddox, creator of IL-2 Sturmovik

IL-2 Sturmovik is a very rewarding WWII combat simulator with highly realistic flight and damage models and gunnery, excellent graphics and eye-boggling effects, attention to detail and historical accuracy, together with a large number of surface objects and flyable and AI planes, and fantastic online play. Add to that the unique setting among WWII sims of the Eastern Front, unprecedented regular interaction of its creators with users, bug-free, stable operation, the consistent public release of patches to implement requested updates for flight models, acoustics, gunnery, etc. and to add on free new aircraft, and you can't help but start to get the impression that the whole project is nothing less than a labor of love. It is no wonder then that it has also become quite popular among WWII combat simulation enthusiasts and earned a very solid reputation among sims.

Chances are that you already know most of that. What you want is to get on your way to winging through virtual but beautiful eastern skies, confidently anticipating the appearance of any who would oppose you. That is one of the aims of this guide: getting you started, be it with overcoming technical troubles, learning about the strengths and weaknesses of the various aircraft, learning how to fly properly, combat tactics, finding resources online, or even other topics. We've really tried to cover just about everything. What this guide cannot claim to be is official. It is not the final word on any of these topics, it really is nothing more than the compilation of experience and carefully considered opinions. You might also learn some things here that go beyond *IL-2* itself, but you'll just have to read on and see.

The purpose of this book then, is not just to get rid of newbies efficiently and prevent some bad habits. Yes, we want to turn you into a knowledgeable virtual combat pilot, and we want you to enjoy it. You'll find, however, that the contents of this guide don't delve very deeply into any of the issues it addresses. There's so much more to discover, and you will soon find yourself developing your own style and tastes, often in contrast to what you find here, and doing your own research. So much the better!

The next chapter, for which writers are badly needed, is planned to give you a glimpse into the horrible historical struggle that is the setting of this fun simulator. The tremendous suffering and appalling loss of life in this theater on a scale so massive it defies your comprehension is awing, and is to be appreciated. However, the goal for this work is to create for its readers a sense of immersion in the sim, so the account ought to focus on the air war and the hardy men and women who carried it out and lived to tell about it.

The chapter "Machines of war" will supplement the generous helping of information you will find in the object viewer (click `View Objects` from the main menu) to provide you with a better idea of the strengths and weaknesses of the aircraft in the simulator, based on user experience.

"Ground school" is meant to ground you in the basics of flight, the things you need to learn before taking off. You will be familiarized with the cockpit and its main instruments, learn how to taxi, clear up some misconceptions you may well have about how an airplane reacts to control inputs, and find out what secondary control surfaces are all about.

The topics covered in "Flight" will prepare you for training and sharpening your skills during training and combat. In addition to an introduction to the critical concept of energy, operation of the aircraft under such normal procedures as take-off, turning, maintaining level flight, climb and descent and landing are all covered. It's probably less tedious than you think. In any case, the theory and skills you learn here are an indispensable foundation for combat maneuvers and tactics. In fact this chapter is limited to cover only the topics immediately relevant to getting an excellent start to actually flying the aircraft, which is why there's a later chapter that continues with the discussion of applying these basics to combat operations.

"Combat fundamentals" introduces the various aspects of developing your state of mind, gunnery skills, awareness of environment and knowledge of the view system and how to find your location. It is relevant to both air-to-air and air-to-ground combat.

"Fighter combat maneuvers" moves on to introduce you to essential and useful maneuvers for fighters. Fighters are aircraft whose purpose is to shoot other aircraft down, and are to be differentiated from ground-attack aircraft. The majority of aircraft in *IL-2* are fighter aircraft. Although many ground-attack aircraft cannot even perform many of these maneuvers, they can benefit from others. Maneuvering is distinct from tactics, and the difference will hopefully become clearer.

"Ground attack and tactics" gets into the basics of the nitty-gritty world of dropping and shooting things into the mud while presenting yourself as a target to bloodthirsty defensive batteries. Eventually it will also bring some of the tactics missing from the chapter on maneuvers. Unfortunately this is not yet written.

The chapter entitled "Advanced topics" picks up where "Flight" left off, goes into further practical detail about flying. Don't let the title fool you, these are still basic topics. However, they are not critical enough to have a high priority in the writing process

The "*IL-2* features and references" gets into some of the details concerning the settings that you can control, organized by menus and starting from the main menu. It goes beyond simply describing the features, offering advice from those who have been there and spent hours learning the advantages gained and making mistakes.

In "Technical hints" you will find information about the various hardware settings, general recommendations concerning the computer-system components and their relevance to performance of *IL-2*, some comments about the flight model, and a few hints about useful external hardware.

The final chapter, "The *IL-2* community," you can read some comments about online resources, notably the main *IL-2*-related websites and basic information and advice about squadrons.

CHAPTER 2

Air war on the Eastern Front

CHAPTER 3

Machines of war

In total with IL-2:FB and IL-2 installation you´ll get 129 aircraft, at least 80 of which are flyable!

— advertisement for Forgotten Battles

There are a lot of planes to learn about in *IL-2*. To be specific, there are 51 Allied aircraft, 36 of which are flyable, and 31 Axis aircraft, 14 of which are flyable. This makes for a total of over 80 aircraft, and for 50 of these you can climb into the cockpit. You can find out a lot of in-depth information on these aircraft at the aircraft section of the official site, from which some of this material has been taken, as well as in the in-game Object Viewer. The goal of this chapter, however, is not to repeat available information, but to provide you with information based on other users' experience with and in-game research on the planes. This includes a general overview of the basic purposes of each aircraft type, what special characteristics they have, how they might be dangerous, what their weak points are, and tips on handling and specific tactics. For an example of how such information is being gathered, have a look at this thread in the General Discussion at the Ubi forums.

There is quite a large amount of information to fill in this chapter. It is being actively worked on, but it takes time to gather the voices of experience together.

Both Axis and Allied aircraft are divided into three sections. Fighters are designed with the purpose of shooting down enemy aircraft. Ground-attack aircraft consist of both dive and level bombers. Aircraft dedicated to transport and reconnaissance are grouped together. Of course some fighters can move mud and even dedicated ground-attack aircraft can be used as fighters in a pinch.

A large number of the aircraft types are unavailable in the unpatched release, but all are available with patch release version 1.2. See section 10.14 for information about patches.

3.1 Aircraft of the Voyenno-Vozdushnyye Sily

3.1.1 Fighters

BI-1 The Berezniak-Isaev rocket-power combat aircraft was intended as a inexpensively constructed, high-speed interceptor to protect Moscow from German bombers. It obviously enjoys a very high speed and exceptional rate of climb, but its low fuel reserves limit flight time and it carries little ammunition. It is also incapable of maneuvering horizontally with propeller-driven fighters. Controls are simple, landings are a challenge, and a short campaign mode is provided.

I-153 The “Tchayka”

I-16 The Polikarpov I-16 ”Ishak,” Russian for Little Donkey, was a mainstay of the VVS at the beginning of the war, but as most VVS was outclassed by the modern Luftwaffe fighters when Operation Barbarossa began in 1941. However, it is quite spry and although it can’t keep up the German fighters’ high speed, it can easily out-turn them and is extremely dangerous up close. The fighter served until 1942, when it was replaced by faster and more modern aircraft.

The I-16, although a monoplane, is quite an old design, dating to 1933, although the in-game models are from 1939. It was the first Soviet fighter to have retractable undercarriage, which had to be cranked by hand. Volunteer Soviet pilots received combat experience in the I-16 while participating in the Spanish Civil War. The enemy pilots rather disliked this pesky fighter and nicknamed it *Rata,* Spanish for rat, a name that continued to enjoy circulation among German pilots after 1941.

The Type 18 fighter is much the same as the Type 24, the latter enjoying a greatly increased armament with the 2×20 mm ShVAK cannons.

LaGG-3 This development of the Lavochkin (La), Gorbunov (G) and Gudkov (G) team had an all-wood construction. It is a capable fighter for its time with excellent maneuverability, but quickly loses speed during hard maneuvers. Slower than the German fighters and not a quick climber, it nevertheless has a strong armament that is better to be well respected. It was replaced by the La-5.

La-5FN Developed from the La-5 after the LaGG-3 (the La-5 is available in *Forgotten Battles*), the new fuel-injected engine and improved structure created an agile Lavochkin fighter with lively acceleration that is one of the faster Soviet climbers. It is blessed with good visibility through its bubble canopy and carries the only two weapons it needs: nose-mounted 20 mm cannons with 200 rounds each, synchronized to fire through the propeller. It serves best as a low- to medium-level fighter, but can carry rockets or light bombs for ground attack.

The La-5FN is well respected by German fighters and was one of the main fighters of the war starting with the Battle of Kursk in summer of 1943. In addition to its acceleration and speed, it has a high turn rate: at low to medium altitudes, it is faster than the 109G's and 190A's and out-turns them both in horizontal and vertical maneuvers.

La-7 The La-7 is the big brother of the La-5FN: faster, more powerful and in all ways downright scary. Introduced in 1944, refinements to the design made the La-7 one of the best front-line fighters at the end of the war, and it enjoyed superiority to nearly every propeller-driven fighter. Available in *IL-2* as AI only, it is flyable in *Forgotten Battles*.

MiG-3 The MiG-3 is a high-altitude interceptor and the fastest of such in 1941. Unfortunately it is weakly armored and catches fire easily when hit. At low altitudes it turns slowly and has poor maneuverability. Many consider it a specialist's plane. It is often underestimated but dangerous and a stable gun platform in its element, and responds well at high angles of attack. With 2×7.62 mm and 1×12.7 mm machine guns, the armament is not strong.

P-39 Also known as the Airacobra, Cobra, Snake and sometimes the Iron Dog, the P-39 is one of the more powerful fighters in the Soviet arsenal. This American-designed and constructed aircraft was provided to the Soviets in large numbers as part of the lend-lease program, starting in 1942. This plane is built around its armament, and with .50 and .30 caliber (12.7 and 7.92 mm) machine guns and a 37 mm cannon firing 3 shells per second through the propeller hub (there are 30 of these rounds), she is well equipped to fight. The .50 caliber guns can fire for 27 seconds continuously, and the .30 caliber guns of the N-1 type can fire for 75 seconds, so you need not spare them.

The placement of such a whopping cannon in a small fighter was made possible by placing the engine behind the pilot, a rare design in its day. This weight distribution and the leftover space up front made the implementation of tricycle gear desirable, and the P-39s are the only planes in *IL-2* with tricycle gear. The engine placement also helps give the P-39 a nasty spin characteristic, which requires a unique recovery procedure (see section 5.9). You'll find she needs little rudder pressure when rolling into a turn. In fact you always want to be fairly gentle on the controls. As one P-39 training film puts it, "You want to treat this airplane like a lady, don't try to be fast or rough if you expect to get along."

The Cobra has an extremely efficient airframe, and as a result does not lose airspeed very quickly. Use this to your advantage in combat. Since the supercharger was not included in production, this plane was not popular among USAF pilots of the high-altitude Pacific theater engagements. Soviet pilots took advantage of its superb low-altitude performance and used it to great advantage, as documented in [1].

You can find a cockpit reference for the P-39 at the Sturmovik101 section of Mudmovers. All three models have a nearly identical cockpit layout.

PZL P.11c This delightful and highly maneuverable plane was hopelessly outmoded at the onset of the Blitzkrieg into Poland. It nevertheless is hard to hit and not to be disregarded.

Yak The Yakovlev series of fighters is one of the most important used by the VVS. A useful overview of these modern, highly maneuverable and well-armed fighters needs to be provided.

3.1.2 Ground-attack aircraft

IL-2 The Ilyushin-2 "Sturmovik" is an absolute joy to fly. Armored like a tank, it is lumbering, but armed to the teeth and able to get air kills, including unwary figthers. It is very difficult to stall, and will not spin. Poor rear visibility is compensated in later models with a rear gunner.

There are a great variety of IL-2 types avaialable in the game: the first second and third series, the field modification, the 2M first and later series, types 3 and 3M, the torpedo-armed T type and the 2I.

There were 36,183 IL-2s built, more than any other type of aircraft in history [2].

Pe-2

Pe-3

Pe-8 The biggest bomber in the game.

Tu-2S

3.1.3 Transport and reconnaissance

G-11

Li-2

MBR-2 AM-34

R-10

U-2VS

3.2 Aircraft of the Luftwaffe

3.2.1 Fighters

Bf-109 E-4 "Emil"; E-4/B "Jabo"; E-7/B "Emil"; E-7/Z "Emil"; F-2 "Friedrich"; F-4 "Friedrich"; G-2 "Gustav"; G-6 "Gustav"; G-6 late "Gustav"; G-6/AS "Gustav"; K-4 "Kurfurst"

FW-190 The Focke Wulf 190 fighter series is one of the two main fighter types for the Luftwaffe. When they first saw action in the skies in 1942 the high qualities of this high-altitude fighter were swiftly recognized, and it was considered by many to be the most superior fighter of that time. There are three types available for you to fly: the FW-190A-4, A-5 and A-8. The FW-190D-9 is present but AI only.

He-162

I.A.R. 80

MC.202 "Folgore"

Me-262 The *Schwalbe,* which Hitler wanted to employ as a bomber, is not flyable in *IL-2*. This beautiful machine was made flyable for *Forgotten Battles*. You can find out more information about it at Stewart's Me-262 Guide.

3.2.2 Ground-attack aircraft

He-111 The Heinkel 111 level bomber is present in the game as AI only. In Forgotten Battles it has been made flyable thanks to the cockpit work by Xanty. You can find out more at Stewart's He-111 Guide.

Hs-129 B-2, B-3/Wa "Waffentraeger"

I.A.R. 81 Dive bomber

Ju-87 The Junkers 87 *Stuka* is possibly the most famous and recognizable aircraft of WWII. Stuka stands for *Sturzkampfflugzeug*, literally "fall-combat aircraft," what we call dive bomber. The B-2 type is flyable with the version 1.2 patch, and the D-3 and G-1 types are AI only. Learn more about this awe-inspiring machine that struck abject fear into the hearts of many at Stewart's Stuka Guide.

Ju-88 This medium-sized Junkers bomber is another well-recognized aircraft. It is capable of both level and dive bombing.

3.2.3 Transport and reconnaissance

Ju-52 The Junkers 52 was the transport cow of the Luftwaffe and could carry 18 passengers, which in wartime often translated to paratroops. Its role in the evacuation efforts at Stalingrad are legendary. Slow and lumbering, it requires a good escort, but if caught unawares it has teeth in the form of defensive machine guns with a good field of fire. There are both land and sea versions of this plane.

Fi-156 The Fiesler Storch is a famous reconnaissance aircraft. Equipped with a rear machine gunner, its disproportionately large wing surface allows it to fly at extremely low speeds and land in a short distance.

FW-189 A-2 "Uhu"

Me-321 Glider transport

Me-323 An enormous transport, used to haul Me-321 gliders.

3.3 Armament and loadout

A great deal of information on armament and especially loadout is available on kajr's Sturmovik101, hosted by Mudmovers. A summary of that information may be useful here, but he's too busy at the moment.

CHAPTER 4

Ground school

A small correction early is better than a large correction late.

—Aviation proverb

I've given it some thought, and have more or less come to the conclusion: you can't be useful in the air, much less good at aerial combat, until you know how to fly an airplane. I would have thought that this is obvious, but I am reminded time and again that it is not. So many eager folks come to the *IL-2* forums wanting to learn the "tricks that will help them win in *IL-2*" or want to learn why they can't land a bullet and always end up a dirt torpedo. The answers offered to specific questions vary in usefulness as well as temperament, but they usually have a common theme: learn the basics, practice, try this or that, then practice it, read this or that article, practice. All I can say is that it's pretty sound advice. There is a lot to learn, but you don't have to learn everything at once. We hope to provide a good beginning here. An introduction to the basics for flying in *IL-2* is here, and the practicing is up to you.

Fortunately for you this is a user's guide and not formal flight training. You won't have to spend countless hours studying and learning before you even get up in the air. Our goal is to get you started discovering and improving your flight sim experience, not to prep you for your private license. Although learning to fly in *IL-2* won't make you able to fly a real airplane, it is realistic enough to demand some knowledge on your part.

Most of us don't have real airplanes, but we would like to learn from the outset in the most realistically simulated environment we can. Hence, in the discussions of this and the following chapter we are going to assume that the realism settings having to do with the flight model are all set in the difficulty options. These are: wind and turbulence, flutter effect, stalls and spins, blackouts and redouts, engine overheat, torque and gyro effects, realistic landings, takeoff and landing, head shake, realistic gunnery, limited ammo, limited fuel and vulnerability. The rest of the settings—cockpit always on, no external views, no padlock, no icons, and no map icons—also have to do with realism, but are concerned with viewing and have little or nothing to do with the flight model.

Some of the absolute introductory basics of flight, namely the forces acting on an aircraft, its axes of movement and the principle effects of manipulating the primary control surfaces—the ailerons, elevator and rudder—are covered in the *IL-2* User Manual [3]. If after reading this manual you are thirsty for more knowledge about how airplanes fly and not too sure where to look, the informative and not infrequently entertaining book *See How It Flies* [4] is a great place to start. It is an online book and, as its author describes, it is a book about the "perceptions, procedures, and principles of flight." We will certainly repeat some things about the basics later on, but first let's have a seat in the office where business will be taken care of.

4.1 Gauges and levers and toggles, oh my!

I remember how I was always impressed when I looked at the instrument panels in cockpits of all kinds. I still am. I have little idea of half the flips and instruments in the cockpits of modern jets, but I certainly have learned a lot about the gauges of the 1930s and '40s. Being able to tell what is going on with your plane from its panel is a vital aspect of being a pilot, and although we will not get into heavy detail, you will greatly benefit from being able to decipher some of the more critical gauges. Keep in mind that all of the topics mentioned here have not been discussed yet; you might want to come back and read this section again after you have learned more about flight basics in later sections. Refer to the illustrations in the instrumentation guide that came with

IL-2 to compare the instruments to your cockpit. You might want to climb into a cockpit of your choice and identify these instruments as you read through the descriptions below.

Altimeter As mentioned in the documentation, this is your altitude above sea level, either in meters, kilometers or feet. The little hand shows thousands and the big hand hundreds, or in German machines, the hand shows tenths of kilometers (hundreds of meters) and the counter at the bottom shows kilometers. Some airplanes had this gauge zeroed to their airfield altitude; this is not so in *IL-2*. It is useful in navigation, combat and any time you are close to the ground.

Airspeed indicator This one is pretty obvious at first glance. It is critical to know the speed with which your aircraft is meeting the air. It's useful in takeoffs, landings, avoiding stalls, flying formation, avoiding structural damage, finding optimal climb rates, and in nearly every aspect of combat. It can also indicate whether your engine is performing up to par, or if something is amiss—damage-induced drag, or forgotten flaps or landing gear. Be careful when interpreting the gauge; it is the indicated airspeed, not the true airspeed, so it doesn't compensate for wind or altitude. Watch the units, too—American-made craft may indicate mph instead of kph (1 mile = 1.6 km).

Artificial horizon Also called the flight indicator or attitude indicator. This gyroscopic instrument indicates the attitude of your airplane, or its pitch and roll, the angles of your nose and wings relative to the ground. If for example you bank left, the line or figure representing the airplane will tilt to the left (left side is lower) in the same measure your wings do. If you raise the nose instead, the line representing the horizon will go lower than the line representing the airplane. If you're in a taildragger on the runway, the horizon line will already be a little below the airplane line. The different gauges represent this somewhat differently, but with some effort you will be able to figure it out. This instrument is especially handy if you can't see the horizon very well. You can't necessarily rely on it to give you an instant orientation when the nose of the aircraft is very far from the horizontal, but after practice you may find it to be a good friend in tight spots. It's a great help when playing hide-and-seek in the clouds.

Climb indicator Also referred to as the variometer. If you make gradual changes in the climb rate, it shows you the rate of climb or descent in m/s or ft/min$\times 1000$. The instrument doesn't react instantly to changes in climb rate. When making quick changes rely on the altimeter first. For instance, many times the altimeter reading is decreasing when the variometer still shows a climb.

Heading indicator The *IL-2 User Manual* refers to this as the repeater compass or remote reading compass. This instrument is purely for navigational purposes, but don't go underestimating the importance of navigation in aviation. The idea is to use the reading to get yourself oriented toward the next waypoint. Yes, the technology for this really existed back then! One needle shows your current heading (the Russian version doesn't have this) and the other shows the direction of the next waypoint. Keep the needle lined up to navigate your course. In planes that have both, the heading indicator can also be a handier reference than the harder-to-read magnetic compass when going through turns, especially in combat.

Magnetic compass Also known as the turn indicator or whiskey compass. You may have used one of these in a forest once; they float in a liquid and point toward magnetic north. In the cockpit they're not always highly legible, especially in stressful circumstances—which are not entirely unheard of in combat aircraft—but sometimes they're all you've got. In some cockpits the magnetic compass is partially or fully obscured by the control stick or other object.

Turn and bank indicator Also called the turn-and-slip indicator, this gyroscopic device provides indirect information about the bank angle of the wings and the coordination of a turn. The ball shows the direction of a slip or skid, so you should "step on the ball". Both are useful for steadying the aircraft to hit targets, especially the slip indicator. It might help you fly turns more efficiently, but not always. It is very helpful in trimming out the plane against slip. Much more to write here...

Manifold pressure gauge This handy but tricky gauge measures the pressure in the intake system of the engine. It is handy because in many circumstances Estimate of the power developed by the engine. With the engine turned off, it measures the ambient air pressure. When the engine is running with the throttle closed the engine creates suction in the intake, and the MP gauge shows a lower pressure. With the throttle wider open it shows a higher pressure. At full throttle the pressure should be again be close to ambient pressure. When ambient pressure, which varies with altitude, and engine rpm are taken into account (the MP reading will increase with decreasing rpm) this gauge is a good measure of power, and can and should be used to set the throttle for a desired power setting. It is also useful for troubleshooting. Usually you cannot develop full manifold pressure in a damaged engine, and you shouldn't want to anyway except in an emergency.

Tachometer This is the engine's speed in revolutions per minute. Airplanes of the era have relatively low engine speeds. In planes that have constant-speed propellers the tachometer is used for propeller governor settings. It is used with the manifold pressure gauge for engine management and diagnosis.

Oil temperature and pressure This gauge lets you know when your engine is warm, when it is normal and when it is cooking. Overheating the engine causes damage, and you can use this gauge to help prevent it. When the oil pressure becomes abnormal the engine is probably damaged. In some planes oil temperature and pressure are shown on separate gauges, on others they are integrated into an engine gauge unit.

Coolant temperature As with the oil, when the coolant temperature goes above the marked limit it is time to think about cooling the engine, just like in a car. If you let the engine get too hot you will hear the engine fluids boiling.

Propeller pitch The Luftwaffe aircraft have a *Luftschraube Stellungsanzeige,* that is, a propeller position indicator. As the pilot varies the propeller control, this indicator gives a measure of the pitch of the propeller, or the angle at which it meets the air. In most applications in German (and other) aircraft you can leave the blade pitch control on automatic. In a few circumstances, you may be able to use manual pitch control to make finer adjustments to the engine management. In most other aircraft, the tachometer (rpm) is used as an indicator of the propeller control. Most of the VVS aircraft use constant-speed propellers, which do not require this indicator.

OWI The outside world indicator is implemented in most aircraft as a large, transparent material, often referred to simply as the "windscreen." Pilots must check this indicator regularly to maintain situational awareness. Under low visibility conditions it can become highly unreliable.

Of all of these instruments, we can identify six that are the most often used in flight: the airspeed indicator, altimeter, artificial horizon, turn and bank indicator, heading indicator, and climb indicator. You may have heard of pilots referring to an instrument scan. This process, which is critical to low-visibility flying, involves the checking of these six important instruments, starting with the artificial horizon, and the decision-making that must be done before making major attitude changes.

4.2 Cockpit orientation

Each aircraft cockpit has its own layout of various gauges, selectors, levers and switches. Some are more advanced and automated than others, and they may or may not seem to make sense. That's how cockpits are though, and the 3-D cockpits in *IL-2* are modeled to a high degree of detail and accuracy, even if every last thing you see is not animated. The P-39N-1 cockpit for example has over 60 items modeled, and these compare closely in placement and detail to the documentation in actual pilot's handbooks. If you would like to find out more about the various items in the cockpit, you can find cockpit reference guides for a few of the planes at [5].

In each cockpit the most important thing is what you find first after climbing into the cockpit: the instrument panel. You should be able to identify a number of items fairly quickly. The most important and frequently needed gauges are usually large and placed near the center of your view. Some indicators that you will recognize from the previous section that are usually highly perceptible are the airspeed indicator, altimeter, artificial horizon, turn and bank indicator and variometer (climb indicator). Get into your favorite cockpit and take a moment to look around and find these instruments by comparing them to the images on your reference card. Keep in mind that not all aircraft has every gauge, although you should always find an airspeed indicator and an altimeter.

The manifold pressure and tachometer are especially important for engine settings. Look for a whiskey compass or repeater compass for navigation.[1] When you plan to be flying a particular aircraft very much, it is definitely worthwhile to learn what instruments are available to you and to have their placement memorized. Stuff happens fast up there, and this greatly aids your ability to gather vital information at a glance.

In most aircraft the controls for the gear, flaps and radiator/coolant cowling flaps, etc. are not animated. Several aircraft do have warning lights that indicate the position of landing gear, and in some aircraft such as the IL-2 there are manual indicators.

The next thing to learn to adjust to life in the cockpit is how to use the OWI indicator (see section 4.1). The point of view rotates around an point in the cockpit meant to represent the position of the pilot's eyes. The mouse can be used to rotate the view smoothly, and the mouse speed can be altered. (From the main menu, click `Hardware Setup` and then `Input`, and enter a number into the `Mouse Sensitivity` field.) You can also use the hat button of a joystick to snap or pan between various viewing angles; pressing F9 toggles between snap and pan modes. You may also choose to have a look around the outside of the aircraft by pressing F2. See section 6.4 for more on changing views.

As you climb into the various cockpits you will notice that the visibility varies greatly from aircraft to aircraft. In some planes the forward visibility is fairly obscured, in others great. Often armor plating blocks your view, sometimes the plating is there but transparent. Some aircraft have bubble canopies and some have terrible rearward visibility. In a few aircraft the pilot sits further forward or behind the wings and enjoys an increased downward field of view. Learn to use the full field of view of an aircraft.

This is true not only of the OWI but also of the indicators in the cockpit. Human binocular vision is not modeled and you can't move your point of view to the side, so sometimes you just can't see a given instrument. Instruments hidden by the stick can be seen by moving the stick well to the side—not recommended practice in critical situations or at low altitudes.

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[1]Unfortunately, some of the compasses are 90° or so off, be sure to compare them to the heading shown in the speed bar.

Type	Model	Altimeter	Heading	Man. press.	Airspeed	Turn & Bank	Tachometer	Prop pos.	Art. horiz	Variometer	Fuel	Oil temp	Oil press.	Clock	Ammo qty.
Bf 109	E4	✓	✓	✓	✓	✓	✓	✓	–	–	✓	✓	✓	✓	–
	E-7/B	✓	✓	✓	✓	✓	✓	✓	–	–	✓	✓	✓	✓	–
	E-7/Z	✓	✓	✓	✓	✓	✓	✓	–	–	✓	✓	✓	✓	–
	F-2	✓	✓	✓	✓	✓	✓	✓	–	–	✓	✓	✓	✓	–
	F-4	✓	✓	✓	✓	✓	✓	✓	–	–	✓	✓	✓	✓	–
	G-2	✓	✓	✓	✓	✓	✓	✓	✓	–	✓	✓	✓	✓	✓
	G-6	✓	✓	✓	✓	✓	✓	✓	✓	–	✓	✓	✓	✓	✓
	G-6 Late	✓	✓	✓	✓	✓	✓	✓	✓	–	✓	✓	✓	✓	✓
	G-6/AS	✓	✓	✓	✓	✓	✓	✓	✓	–	✓	✓	✓	✓	✓
FW 190	A-4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	A-5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	A-8	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ju-87	B-2	✓	✓	✓	✓	✓	✓	–	–	✓	✓	✓	✓	✓	–

Table 4.1: German cockpit instruments

4.3 Starting up

In *IL-2*, starting the engine is a snap—you just press `I` on the keyboard. Unfortunately, you cannot start the engine with a simulation of the procedures it took to get those powerful engines revving. There are all kinds of controls and checks before, during and after starting and warming up the engine that are standard procedure. This was often a difficult aspect for the ground crews on the Eastern Front during winters. Sometimes they would light fires under the fuselage to get the engine warm enough to turn over.

There is, however, one aspect that you as a virtual pilot have to consider, and that is when going online. In an online coop mission (dogfight server?) you should not touch the engine controls while the mission is loading, nor for the first two seconds or so after it is loaded. If you do this you risk randomly damaging your engine! This is a known bug.

4.4 Checklists

We all forget. Checklists are there to help you prep your plane for flight and carry out simple maneuvers such as takeoff, climbing, cruising and landing under various conditions. This is something the 1C:Maddox team chose not to develop for their planes, and given the amount of work required to make historically accurate checklists for the large number of aircraft the choice is understandable. The reasoning is that the vast majority of flight simmers are not ready to give the time required to go through real checklists, which are pretty detailed: you have to check brakes, electrical equipment, control surfaces, landing gear, cowl flaps, fuel selection valves, propeller, mixture and throttle settings, then go through a precise engine startup and warm-up procedure and observe that everything reacts properly. That is just the pre-flight checklist. There is detailed documentation out there for your airplane, but no in-game lists.

You may wish to make some simplified checklists of your own. Some things that you do want to learn to do before taking off are: allowing the engine to warm up somewhat, checking control surfaces to make sure your controllers are connected properly, setting your view, applying brakes before increasing throttle, making sure that nothing is obstructing your path, and deploying the flaps to the desired setting.

4.5 Taxiing

Way up in the sky, airplanes are elegant and doing what they do best. On the ground, they are clumsy at best and have poor forward views. Taxiing is performed at low speeds, not much faster than you can walk. The faster you taxi, the faster your airplane will become unstable. Keep in mind the quotation at the beginning of this chapter.

To get the airplane to maneuver on the ground, you must use the thrust provided by the engine to go forward. The propwash also flows over your rudder, so you can use it to steer. Before you start moving though, a further word on steering. The rudder is the only primary control surface used to maneuver on the ground—you can keep your hands off the stick until you are ready for take off. Moving the rudder pedal to the left[2] steers you toward the left, and vice-versa. For gradual

On the ground, steer with the rudder.

[2] If you do not have rudder pedals, use the twist action of your joystick or the keys for rudder control (the . and , keys by default).

turns the rudder alone will often provide you with sufficient steering control. The faster your forward speed, the more authority the rudder has (and the more danger you are in of an accident). You will probably notice this during takeoff.

At the low speeds used for taxiing, sometimes the rudder is not enough to turn sharply. For sharper turns the planes are equipped with a differential braking system, which is handy since your ground crew is never to be found. There is only one control for the wheel brakes, so the differential braking is activated by the rudder input.[3] If you want to turn left sharply, give full left rudder and then apply the wheel brake control. Holding the wheel brake for too long is not usually good unless you want to stop the plane. To turn even more quickly, you can give quick bursts of throttle. Note the following from [6]: "Turning the airplane with one wheel locked is very bad practice, as it grinds rubber from the tire and may overstrain the spindles of the main landing gear to a point where they will later fail on landing or take-off." In addition, overbraking can quickly heat up the braking surfaces and glaze them. In the sim we are not constrained to worry about such things, and you can adopt the bad practice of overbraking liberally. Be careful though, too much braking can cause a nose up, causing a prop strike or even flipping your airplane.

Brake softly but liberally.

To start moving, make sure that the tail wheel is not locked and clear the engine with a burst of thrust (this latter is more a real-world procedure). You will need a fair amount of thrust, but once the plane starts moving, back off on the throttle to about 10–25% thrust (real-world procedure calls for a certain amount of rpm), depending on the airplane, your load, and how fast you want to go. If you start to go too fast, just ease the throttle to idle and gently apply the brakes. It is generally recommended to open the oil and coolant shutters (use R) when taxiing.

Most modern-day airplanes have tricycle landing gear and fairly good forward visibility on the ground. Of the flyable planes in *IL-2*, only the P-39 enjoys this advantage.[4] The other planes have the third wheel at the tail of the plane and are known as taildraggers.[5] In these

[3] If you have rudder pedals that support toe braking, you can assign one of the toe-brake axes to the wheel brake HOTAS. Such a slider control gives you various degrees of braking. Otherwise you can use the keyboard (B by default).

[4] The nose gear of the P-39 is also coordinated with the rudder to give it additional turning ability.

[5] Although also technically a taildragger, the BI-1 also has good forward visibility.

planes you will have to be much more careful. Normally you cannot detect anything directly in front of you, including parked planes. Since you don't have anyone to walk your wing, you will need to turn the plane to one side with the rudder (and brakes if really necessary) and a burst of throttle, so that you can see any objects in your path through the front quarter panel of the cockpit. Be sure to take advantage of the engine torque by turning to the side the plane naturally swings toward. Again, be careful to unlock the tail wheel before carrying out this procedure, and to lock it again after having started moving forward for takeoff.

4.6 Attack!

Those first few sections were all okay, but now we're coming to the really practical stuff. You're about to be prepped for learning how an airplane really flies. The first thing we have to do is get used to the idea that we're going to be controlling a vehicle that moves about through the air. So before you get into the air, there's something you ought to know about controlling the airplane: it's not a car. Really, it's not. In a car, to go faster you give it more gas, or maybe shift gears, but in an airplane there is an extra dimension of movement, and it's a little more complex. For instance, opening up the throttle might not change your airspeed much at all. (This is so in a car as well when the car is headed up a hill.)

There's another misconception you might be under, and that is that pulling and pushing on the stick makes the airplane go up and down. What it does do is cause the elevator,[6] or flipper, to deflect up and down, respectively. The change in lift of the deflected flipper causes the pitch of the airplane to change in the direction of the deflection. That's what pushing and pulling on the stick does: it changes your pitch. The stick seems to work as an up/down control most of the time, but the truth is you have to work with the stick and the throttle together to determine airspeed and change altitude. We'll come back to this.

Alright, so much for those misconceptions. Understanding more correctly what does happen will pay off, so let's be a little more precise. We'll start with an example. Imagine an airplane flying along in level flight, meaning it is flying straight ahead without changing speed or altitude. In fact, have a look at the first picture in figure 6, where a

[6]This name is somewhat of an unfortunate misnomer, since it gives a wrong impression of the function.

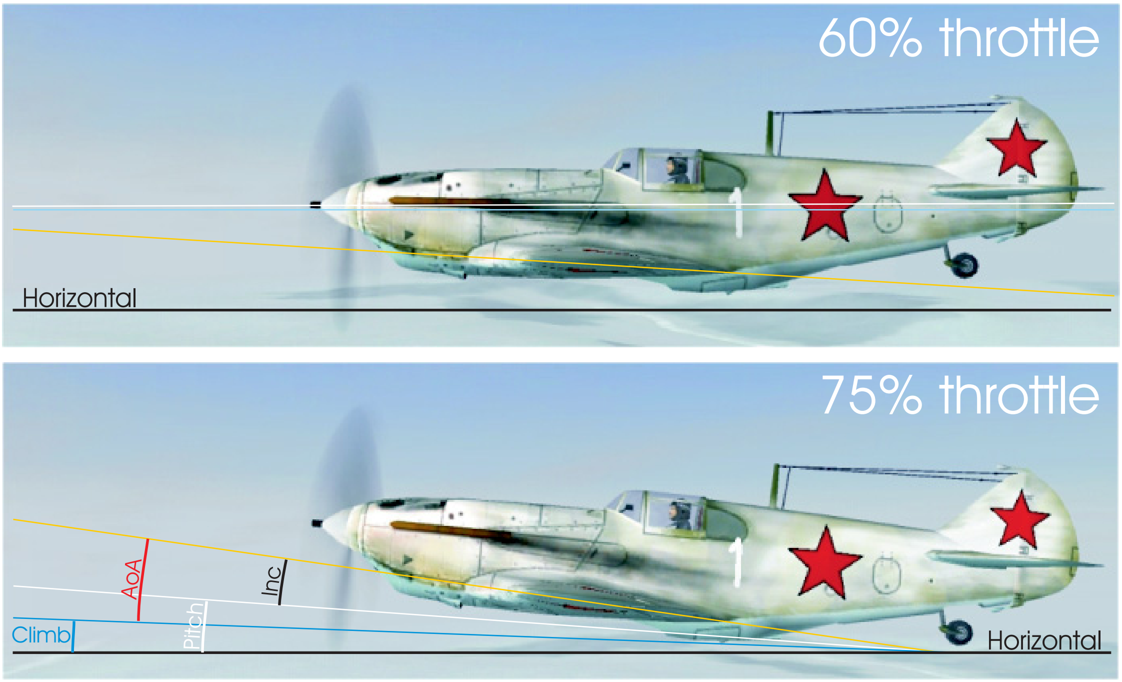

Figure 4.1: In the first picture, Oleg is flying his LaGG-3 in level flight (see section 5.6) at about 310 kph. In the second, he has smoothly added throttle and begun to climb. It is clear that the angles of pitch and climb have increased, although the angle of attack has not. The airspeed has not appreciably changed.

man—for lack of a better name let's call him Oleg—is cruising along on a frosty winter afternoon in a '41 LaGG-3 at about 310 kph. Oleg's fighter is in a state of equilibrium, meaning that all forces are in balance, and if you look carefully, you'll see that as it moves forward the wing is meeting the air at a certain angle, called the *angle of attack*. This angle of attack is so important to understand[7] because it affects so many things. A good definition is "the angle at which the air hits the wing." [4] Simple enough, but let's make sure we understand that. How does one figure out what the angle of attack is? There are three things that determine it, which we are getting to.

Angle of attack

An angle is measured between two lines, and for our purposes our two lines are the chord line and a line representing the direction of the relative wind. Picture the chord line as being the line between the lead-

[7]The only instrument in the Wright brother's first plane measured angle of attack [4].

ing edge of the wing and the trailing edge of the wing; look closely at figure 6, where in both pictures the chord line is represented by an orange line. The chord line doesn't change relative to the aircraft unless you change the shape of the wing. A notable example is when you change flap positions (see section 4.7).

The direction of the wind relative to the aircraft changes often. The relative wind has less to do with wind relative to the ground and everything to do with the direction of air movement relative to the airplane.[8] It depends on both the direction of the movement of the airplane in the air and the movement of the air itself. In *IL-2* it's often the case that there is no wind, so let's take the relative wind to be the same thing as the direction of motion of the airplane. The relative wind is represented by a sky-blue line in the figure and is considered to be the same thing as the direction of flight.

Now in the bottom part of the figure, you can see that the LaGG's nose is pointed slightly up and Oleg and his aircraft are climbing.[9] The airplane is headed in the direction of the blue line, even though it is pointed in the direction of the white line. The orange line is still lined up with the chord line, and the black line is level with the horizontal direction, perpendicular to gravity. All of these lines make up important angles that are going to help us figure out the angle of attack:

$$\text{Climb} + \text{Angle of attack} = \text{Pitch attitude} + \text{Incidence}$$

Incidence, labeled as Inc in the figure, is the angle between the direction the plane is pointing (its longitudinal axis) and the chord line. Pitch is the angle between the axis (direction the plane is pointing) and the horizontal. Climb is the angle between the direction of flight and the horizontal. Angle of attack (AoA) is as before the angle that the wing is meeting the air, that is the angle between the chord line and the relative wind (again, here the relative wind is taken to be the direction of flight).

The simplest case is in the first picture, in level flight at cruise speed. The angle of climb is zero, and so is the pitch, so the angle of attack is just the angle of incidence. When the airplane is climbing, if the airplane is pointed in the just the same direction as the climb (this will be the case if it is climbing at a certain optimal speed), then the angle of attack will be the same as it was in the case of level flight at cruise

[8] Einstein would be relatively proud.

[9] Actually you can't see that they're climbing, but they are. If you understand why you can't see it, you're well on your way to understanding the lessons of this section.

speed. In fact, this is probably close to the case in Oleg's climb in figure 6: assume that the angle of the LaGG's climb is the same as the pitch attitude, and you'll notice that the angle of attack is the same as the angle of incidence.

Now how did Oleg get into that climb in the first place? To answer that, let's go back to when Oleg was in level cruise.

It's a beautiful afternoon and the sun is low in the sky directly ahead, but there are bandits about. Not content with things, Oleg increases the throttle setting. Does he go faster? You might be in for a surprise. His plane immediately starts to climb, and the airspeed indicator still shows around 310 kph! Here's a hint: the flight model isn't wrong, real airplanes behave this way too. What happened? Increasing the power does pull the plane forward, but the trim tab immediately reacts and changes the pitch, so the wings convert the added power into altitude (see section 4.7). If you don't understand that yet don't sweat, the main thing is to notice that *the throttle controls power.* What is that power good for? Three things:

Throttle controls power.

1. Overcoming drag to maintain speed and altitude, which is necessary most of the time
2. Climbing
3. Speeding up

Had Oleg wanted his LaGG to speed up but maintain the current altitude, he would have added throttle and at the same time pushed the stick slightly forward. Burn this into your brain:

> The stick and the throttle work together to determine airspeed and altitude.

The stick, together with elevator trim, controls angle of attack, and in so doing determines airspeed. Airspeed is linked to altitude by means of the power curve, and because you can convert between the two. We'll see more about this in section 5.3. The throttle controls power. (Is that burned in yet?) We put an engine in the airplane so that we can overcome drag, speed up, and/or climb.

The majority of this discussion is parallel to [4], where the topics are covered in more detail. This discussion is geared to meet our needs in *IL-2*, but if you'd like to learn more, you know where to look.

4.7 Secondary control surfaces

Alright already, can we get into the air now? You poor little newbie pilot. It's good that you're so eager! However, we've put off discussing take-off until section 5.4 for good reason. There is still some critical stuff to absorb. Before you actually take off, you have to realize that often you can't do everything with the stick, rudder pedals and throttle. In fact, often these controls alone will not be enough to even get your plane off the ground. Besides that, you're going to have to maintain steady flight without wearing your arms out. To help where we otherwise couldn't help ourselves, we have secondary flight surfaces. How are they different from the primary ones, then?

4.7.1 The effect of primary flight control surfaces

The ailerons, elevator and rudder are the first things you hear about when learning how to control an airplane. What they actually do is to create drag and/or change lift to shift the equilibrium of the aircraft, thereby creating forces that change the way it moves through the air. Just to make sure we know the effects of deflecting these surfaces, let's go over them quickly.

Let's consider the ailerons first. When in level flight you move the stick left, you expect the plane to bank to the left, and it does, but why? The aileron on the left wing has been deflected upwards and the aileron on the right wing has been deflected downwards. As a result, the left wing loses some lift and is also deflected downwards, whereas the right wing gains lift and is deflected upwards.

The flipper, or elevator, is controlled by pushing or pulling on the stick. When you pull on the stick, these surfaces are deflected upwards. The airstream over them is deflected upwards, resulting in a new downward force on the tail of the plane. This force also causes the nose to pitch up, changing the angle of attack.

If the right rudder pedal is pushed forward (the left one will move back), the rudder will pivot outward to the right-hand side of the plane. The airstream will be deflected towards the right, and create a force pushing the the tail in the other direction—a clockwise direction looking from the top view of the plane. This force causes the tail to swing (yaw) in that direction, the pilot might think "to the left," and the nose will yaw to the right.

There are variations in the designs of primary control surfaces, but

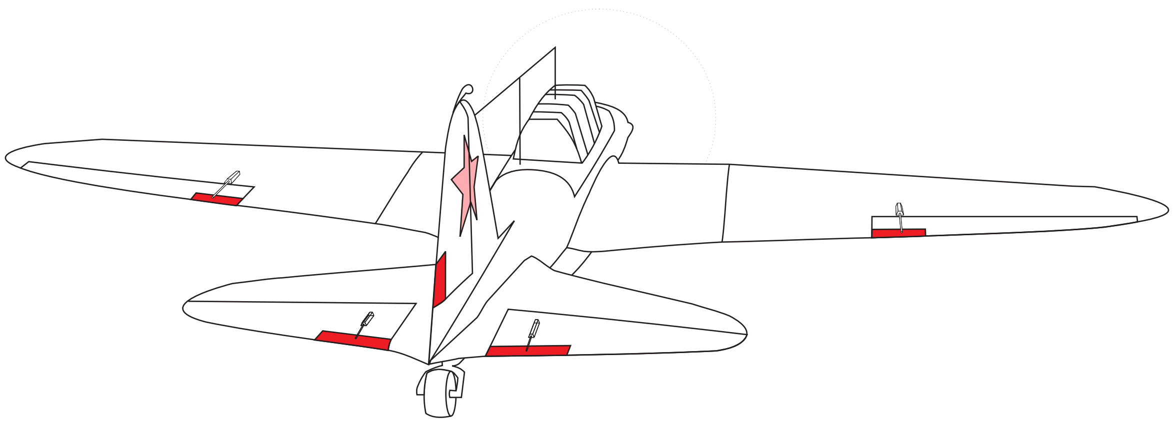

Figure 4.2: The IL-2 models have particularly interesting looking trim tabs, marked in red. The hydraulic tab-operating systems are nicely animated.

for our purposes this is what we need to know. As it turns out, in most planes you can control these surfaces with other means than the stick and pedals. There are also very good reasons for doing so.

4.7.2 Trim

On the primary control surfaces of most planes there are secondary control surfaces called trim tabs. You can see an example of the trim tabs in figure 4.7.2. Moving these tabs in one direction will cause a force that moves the primary control surface in the other direction. The most important of these secondary control surfaces is easily the elevator trim tab, because it helps determine the angle of attack. The trim mechanisms for rudder and ailerons work in a similar way, so let's consider how elevator trim works, and the major whens and hows of applying it.

Figure 4.7.2 depicts an elevator airfoil seen from the side. On the rear upper surface you can see that a part on the trailing edge of the airfoil has been hinged or bent upwards. In fact the bent part of the airfoil is not all along the edge, but only a fraction of the width of the edge, like the tab you can see on the rudder. The result of this tab being hinged upwards (and held in place) is the deflection of some of the incoming air upwards, creating a downward force on the elevator airfoil. This force pushes the elevator down (not shown in the figure). In fact, this is very similar to our earlier description of the way the stick and elevator work together. The difference now is that the tab is located on

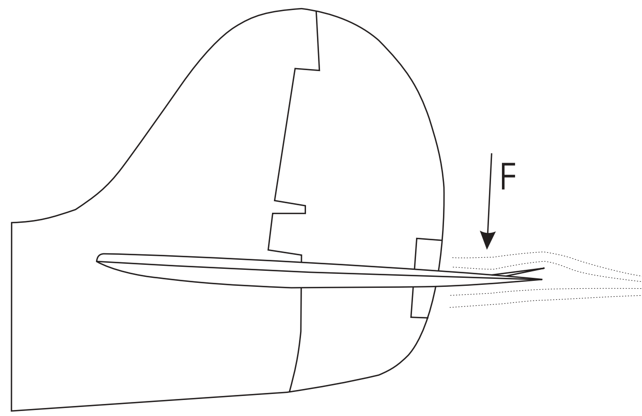

Figure 4.3: The effect of moving a surface on the elevator airfoil upward is a downward force on the airfoil.

the elevator, so if the tab is moved upwards, the resulting air pressure pushes the elevator down. The result of this is the same as if we had pushed forward on the stick: a decrease in the angle of attack.

The actual trim tabs of the primary control surfaces are not typically bent, but rather pivot around a hinge in positions controlled by a mechanical system, possibly by hydraulics. The advantage of this mechanical system is obvious: we can control the position of the primary control surfaces without having to manually put pressure on the stick. We already know that the elevator is used to control the angle of attack of the airplane. This means that an airplane is trimmed for angle of attack. If you trim an airplane and then leave it alone, it will continue to fly at a certain angle of attack. This is also true of airplanes without trim mechanisms, they just aren't adjustable. This is something that you should never forget. Use the elevator trim to set the angle of attack. Trim for angle of attack.

> Trim for angle of attack. Airspeed depends on angle of attack (and load factor).

Why don't we try a simple experiment to illustrate. Use the Quick Mission Builder (see section 10.8) to hop into the cockpit of your favorite fighter. For this experiment you probably won't want one whose variometer is blocked by the stick (like the MiG). Set it for any altitude your heart desires, but give yourself at least 500 m. Set the throttle to about 50%, and try to fly straight ahead without gaining or losing altitude. By default, `Ctrl+Up Arrow` will provide positive elevator trim (like pushing on the stick), and `Ctrl+Down Arrow` negative (pulling). You probably will have to use some slight forward stick pressure, so fool with small trim inputs until you are satisfied that you are flying pretty level. Get it to where you don't need to put any forward or backward pressure on the stick, maybe just a little rudder and/or side pressure on the stick. Steady? Good, the airplane is now flying at its current trim speed. Get your view to where you can see the stick, the airspeed indicator and altimeter, the variometer and the horizon out the windscreen. Now give in a small amount of positive elevator trim, only 2 taps on the keyboard. If you watch the stick, you'll notice that it moved back slightly but immediately. Some other things will follow: the nose will go up, the plane will start to climb, and the airspeed will drop. After the plane has more or less stopped or slowed its climb, check your airspeed and give it two more clicks up. After it stops or slows its climb again, check your airspeed and give it still two more clicks up. You'll have noticed that your airspeed has significantly dropped. Maintain this airspeed for a while, although the aircraft may want to lower its nose and pick back up some of the airspeed, then raise the nose again and lose some of the airspeed, and so on. After a little while, start giving clicks back down if you like and watch your nose drop and airspeed start to climb.

You can try variations of this experiment at different throttle settings. Set the throttle and settle into level flight or a steady rate of climb or descent, then change the trim.

To understand these experiments more fully you should read section 9.1.2 on phugoid oscillations. There it is explained why the aircraft tends to change both airspeed and altitude in an alternating pattern. The more dramatic your change in trim, the stronger those oscillations will be.

Another good trim experiment is described in [4]: "If you want to make a temporary increase in angle of attack, just raise the nose by applying a little back pressure on the yoke [stick]. When you reach the new pitch attitude, you can release most of the pressure, and for the first few moments the airplane will maintain the new pitch attitude. Then, as it slows down, you will need to maintain progressively more back pressure in order to maintain the new pitch attitude (and new angle of attack). After a few seconds things will stabilize at a new pitch attitude, a new angle of attack, and a new airspeed. At this point, if you release the back pressure, the airplane will want to drop its nose so it can return to its trimmed angle of attack."

Rudder trim works the same way but for the yaw axis. If you did the experiment in a fighter that has rudder trim, you could have set a few clicks of right or left rudder trim (depending on the direction of propeller rotation) instead of holding the rudder in place manually with the rudder pedals (or joystick twisting action). Using rudder trim compensates for that ever-present yaw (see section 5.5).

Aileron trim doesn't have much use in normal flight, but can come in handy if a few holes get punched into one of your wings. Applying aileron trim can help hold your plane level without you having to put in constant stick side pressure. If you think this is annoying in *IL-2*, just imagine the force it required in a real plane.

The thing about trim is that it's really necessary, and you need to be concerned about it all the time. Every time you change power settings you need to think about adjusting your trim for angle of attack. As your airspeed changes, the forces on your rudder change and, if you are fortunate enough to have it, you need to readjust yaw with rudder trim. Changes in load factor require retrimming, such as after dropping external fuel tanks or a payload. Even in cruise you have to trim to adjust for changes in the fuel load (check this). It is not necessary or practical to mention every instance here; trim procedures will continue to surface in further discussions.

It is important to realize that the primary control surfaces and the secondary control surfaces work together. Trim is an extension of stick or rudder input. To make long-term changes, you should first use the primary controls. Taking the example of elevator control again, you should initiate a change in angle of attack with the stick until you get the angle you want, and then relieve the pressure needed on the stick with trim input.

> Initiate surface control changes with the stick or rudder pedals, then trim to relieve the pressure.

Note that stick forces are modeled in *IL-2*. The force on the elevator caused by trim will hold the elevator in place, and the virtual stick (not your joystick) will stay in its new position. This becomes important in later discussions, because trim can be used to overcome the stick forces that limit the effect of your joystick input.

Some planes do not have trim for all surfaces.

It has been hinted at that not all aircraft have trim on all surfaces. More accurately, their trim is not pilot-adjustable, but historically was performed by the ground crew before flight. German fighters—specifically the Bf 109 and FW 190 series—have elevator trim only, no rudder or aileron trim. Your right leg will become larger than your left after all those long missions holding right rudder. The Polikarpov I-16 and some others have no trim on any of their control surfaces.

4.7.3 Flaps

In the early days of aviation, aircraft developers needed a way to stabilize aircraft at low speeds, as it was common for them to go into a spin. A slot system was developed by Handley Page, and this led to the development of flaps on the wings, which when extended provided extra lift and increased drag to allow a lower landing and takeoff speed. This feature came to be applied more and more as they began to build planes that were faster and heavier—a way was needed to allow heavy aircraft to safely fly slowly enough to land. By the second World War, flaps had become a standard feature.

This means that when you deploy flaps and other high-lift devices,[10] you can expect two things to happen: the aircraft will get a boost in lift at the price of increased drag. It is important to think not just of lift or drag, but to recall that there is a ratio of lift to drag—textbooks talk about the coefficient of lift and coefficient of drag. Interestingly enough these both depend mostly on angle of attack, but of course extending flaps alters both drastically. The extra drag means that you will either slow down or have to decrease the rate of climb to maintain airspeed. This is also a benefit of course. The extra lift means that you can fly more slowly without reducing the rate of climb (or increasing the rate of descent, as you like). The lift gained also means you can climb more steeply. (See section for more information on how flaps affect climb.) Alternatively, after deploying flaps you can increase thrust if the engine permits to maintain airspeed and/or rate of climb.

Flaps thus afford increased stability at lower airspeeds and can also be used to brake the aircraft. Since they produce a significant amount of drag, there is tremendous pressure on the flaps when they are deployed in flight. If you try to deploy them at high speeds or gain too much speed with them deployed, things will break. Often what happens is the flaps get stuck in their current position. As a result, each aircraft

[10] High-lift devices include flaps, slats and slots. To find out more than the introductory comments here, have a look at Andy Bush's highly informative article, *Secondary Flight Controls – Flaps* [7]. Many of these device designs are present in *IL-2*, but they are referred to collectively as flaps for simplicity.

has a maximum speed for the deployment of flaps. Unfortunately, for the time being you are left to guess what that speed is for each aircraft, but with reasonable precaution it should not pose a problem.

The flaps on each *IL-2* aircraft have four different default positions, and they can be deployed in two different ways. One way is to switch between the positions with keys: pressing V moves the flaps down in increments and F moves them back up. The four default positions are closed, combat, take-off and landing. These positions resemble the actual deployment positions of the aircraft and are sufficient for almost any situation. The use of the individual positions will be discussed later in their appropriate contexts. Should you find a reason for it the second way is to assign a slider control to the flaps in the HOTAS setup (see section 10.2.1). This provides a finer degree of control over flap positions. Looking at the aircraft from an external view shows the various flap positions.

Flap positions

CHAPTER 5

Flight

Maintain thine airspeed, lest the ground arise and smite thee.

—Aviation proverb

Stop for a moment to consider all that you've learned so far: how to tell what is going on from the instruments and gauges; starting her up and getting in position, all kinds of theory about how to control airspeed, and about control surfaces. You'll surely want to actually go for a ride now. First we need to make sure you know how to do two more things: stay up in the air and change altitude. Then it's a cinch to take off, find your way around the sky and gently become reacquainted with the tarmac.[1]

5.1 Stalls

There's an aviation adage that says takeoffs are optional, and landings are, sooner or later, mandatory. What goes up must come down. This is, in fact, usually the scariest aspect of flight. It won't surprise you then that there are basically two ways to land: the way you walk away from (controlled landing) and the way you don't (bad landing). One of the

[1] It's true. In *IL-2* the weak of heart can choose to start and finish in the air and have nothing to do with the ground except under tragic circumstances.

big factors influencing the type of landing you end up with is called a stall, and that's why it is being covered first. As a combat pilot, you will have to worry about other factors that influence your type of landing as well, such as bullets, flak and collisions, but we'll worry about those in the next chapter. Another important phenomenon that probably causes more virtual deaths than enemy fire and is directly related to stalling is the spin, and is covered in section 5.9. Right now it's important to understand what a stall is so that we can know how to stay in the air. It will prove very useful in later discussions about takeoff, landing, and combat maneuvers.

Editor's note: This paragraph needs to be re-examined, as it has been reported as having errors. In other words, don't expect to be able to believe what you read here. Let's bring back our picture of level flight in the section about angle of attack. If for whatever reason the vertical forces keeping your airplane in this equilibrium change, it will respond to that change all by itself by changing its angle of attack, which up to a certain point will change the lift on the wing. Let's illustrate: gravity is acting on the airplane with a downward force, and the wings are producing the force of lift to counteract that force of gravity, so that the airplane does not fall. Now let us suppose that the airplane suddenly gets heavier, or even better, that it suddenly loses some of its lift. Without any help from the pilot, the angle of attack will increase, produce more lift, and restore the vertical equilibrium. Earlier we said this works up to a certain point. That's right, there is a certain angle of attack beyond which increasing that angle will no longer longer result in an increase of lift. It is at this *critical angle of attack* that the airflow over the wings breaks loose, separating from the wing (turbulence instead of laminar flow), and a stall incurs [7]. Note that well:

Stall is a function of angle of attack, and not of airspeed.

Airspeed does play a role, since you can continue to "fly in a stall" at angles of attack greater than the critical angle,[2] but you cannot continue to fly at airspeeds lower than the stall speed. Anyway, since beyond this critical angle of attack no additional lift is available to restore the vertical equilibrium, the force of gravity will begin to accelerate the airplane toward the earth, and control of the airplane can even be lost. Sound scary? It can be, and at any rate it's definitely not something you want

[2]Although this becomes nearly impossible for mere mortals.

to do in a combat situation.

Yet another aviation proverb goes as follows: "If you want to go up, pull back on the yoke. If you want to go down, pull back a little more. If you want to go down real fast and spin around and around and around, just keep pulling back [4]." Now in a fighter with enough speed you might do just this under certain circumstances, but without the part about falling fast and spinning.[3] The point here is, if you keep increasing the angle of attack to the point you lose a significant amount of lift, your plane starts to accelerate—not just to descend at a controlled rate, but to accelerate—toward earth. This can happen not just in level flight or slow speeds, but in any maneuver and at any airspeed. We'll find out more about how relevant this is later on.

So, what leads to the condition of an angle of attack that will cause a stall? The practical answer is, it varies from aircraft to aircraft. Each airplane has its individual stall (and stall recovery characteristics). *Editor's note: could contrast the examples from the P-39 and P-40 pilot's notes. There is certainly that can be added here...*

5.2 Energy

You may have already asked yourself, "What does energy do for me anyway?" As it turns out, energy doesn't *do* anything, energy *is*. You might instead think of it as something your aircraft has. Have you ever read something to the effect of, "When you're fighting, you've got to keep your E." Well now you know: E stands for energy. Understanding the energy your aircraft has and in what forms is key to knowing what to do next to control your aircraft.

What is our coveted friend E in the context of flight? Of all the kinds of energy that are out there, aviation generally involves four: kinetic, potential, chemical and what we could call dissipated energy. Kinetic energy is the energy an object has when it is moving, such as a ball thrown through the air. It depends on the mass and speed of the object. If you want to calculate it, it is $E_k = \frac{1}{2}mv^2$, where m is the mass and v is the speed. (Don't panic if you hate math.) Potential energy is the energy an object gets from gravity. It is also simple to calculate: $E_p = mgh$, where m is again the mass, g the acceleration due to gravity (9.8 m/s downward), and h the altitude, or change in altitude if you want to calculate the difference in energy between altitudes. Chemical

[3] We hope.

energy is the energy stored in the fuel. It is a little more complicated to calculate, but you could make a conversion factor as a function of altitude and mass of the aircraft and the volume of fuel burned [4]. Dissipated energy is the energy the aircraft gives to the air it moves through. You could think of this as energy lost as heat. It too is more complicated to calculate… but then again, we're not here to calculate, are we? All that we need is the understanding that our aircraft always has an energy state, and that it is necessary for us to be aware of what that energy state is and how to exchange between the types of energy.

Of course you can and will change the energy states. An often heard analogy is that energy is like money in a bank account. You can deposit and withdraw, and even if you don't always need to carefully calculate, you have to keep your balance up. As with your bank account, you normally want to keep your energy as high as possible. Altitude and airspeed are like having money in the bank and fuel in the tank is like money in savings, but in all situations you have to pay for drag, like paying for rent. Some aircraft have to pay a higher rent than others. You as pilot can convert between the different forms of energy. You can trade altitude for airspeed and vice-versa quickly, and you can use fuel to gain altitude, airspeed and pay the rent. Energy is better conserved when you do this smartly.

Energy is also related to but different from something else you've already heard of—power. Remember that the throttle controls power? Power is, quite simply, the rate at which energy is used. A 60 Watt light bulb is one that burns 60 Joules per second.[4] So power is energy over a period of time. When we say power, we're talking about how fast we are gaining, losing or converting energy. When we speak of an engine's horsepower, we are indicating how fast that engine can overcome the aircraft's inertia to convert fuel into the other forms of energy, namely airspeed and altitude. Let's not get into inertia.

5.3 Changing altitude and airspeed

Climbing, descending, speeding up and slowing down are all a matter of managing your account at the First United Energy Bank—you'll be trading in one form of energy to gain another, and paying the rent (what a drag). In fact this is so energy related, it is really an extension of the

[4] A Joule is a standard measure of energy, just like a second is standard measure of time, or 1 Watt = 1 Joule/ second.

previous section. Since you will change energy states at a given rate of time, we can talk about the power involved.

This has already been emphasized in section 4.6, but it is important to realize that you have to work with the stick and throttle together to control your airspeed and rate of climb or descent. The concepts of angle of attack, energy and power come to our aid here. To make controlled changes in altitude (climb and descent), you will have to watch your airspeed. To make changes in your airspeed, you will have to watch that you don't unintentionally change your altitude. To climb optimally (and the meaning of optimal depends on your goal) you have to watch your airspeed closely, which you will of course control with angle of attack and throttle setting.

Recall that you trim for angle of attack, which determines airspeed.[5] We have gotten out of our minds now the concept that the stick is the up/down control for the airplane. This misconception is due to the fact that it seems to work in most conditions. Let's now look at it more closely in a practical situation. You are flying along en route to your mission at 2500 m and 280 kph, when the change in waypoints for some reason only your CO understands calls for a change of heading and an altitude of 2800 m. After you have turned to the new heading you will need to climb. What will you do?

There are a couple of ways you can climb to the new altitude:

- You can pull back on the stick and hold it there. In the described situation you are in cruise and have enough airspeed to trade some of it for altitude. This is called a zoom climb. So you pull back on the stick until you have climbed 300 m, but now realize that your airspeed is pretty low. You will have to throttle up to get back to the desired airspeed. If you don't, your airplane is unlikely to maintain the new altitude.

- You can open the throttle up. As we found out in section 4.6, the plane will start to climb without increasing its airspeed very much. Once you have the new altitude you can reduce throttle and resume level flight. Don't think you won't have to touch your control stick, though.

[5]Together with load factor, which includes bombs, ammunition and fuel, and more significantly the positive G force during turning maneuvers. However for our present discussion we will not concern ourselves with load factor.

Which is better? In this example situation the first possibility seems to be an awful lot of hassle. And what if you had had to climb to an even higher altitude? It's pretty clear that you need more throttle to climb. Had you already been flying with full power and needed to gain altitude, then the first option, that of pulling back the stick, would be the only one open to you. However, under normal flight conditions you need to increase your power setting to gain altitude. You also vary the angle of attack with the stick and trim to achieve the airspeed desired for climbing. You might or might not already have guessed it, but the airspeed is linked to the way the airplane climbs.

If you choose the second method, then to climb faster (more vertical meters gained per second), you could change the airspeed to the airspeed corresponding to the maximum rate of climb. This is called V_y and as it turns out might not be very different than your given cruise speed. (No, we haven't yet said how the airspeed affects climb rate.) If in the example you were cruising at 280 kph and the airspeed for optimal rate of climb were 300 kph, then you might actually put the nose ever so slightly *down,* add power and upon gaining the extra 20 kph, make small pitch adjustments with the stick and trim to keep the airspeed at 300 kph.

If you again choose the second method but instead would like to steepen the climb (more vertical meters per horizontal meter), you could hold the stick back a little while adding throttle. This will slow you down and you won't climb as quickly in a steady climb. There is also an airspeed V_x that corresponds to the maximum climb angle.

In a zoom climb (trading airspeed for altitude), the steeper the pitch the faster you'll trade airspeed for altitude, the limit being a purely vertical climb. Make sure you understand the distinction from a steady but steep climb. You can trade in excess airspeed for increased altitude in a zoom climb. However, if you are maintaining airspeed in a steady climb, then setting a higher pitch for a lower airspeed will help you climb more steeply although not more quickly. Of course there is a limit to the steepness and lower airspeed, which makes sense.

In any case, whether you zoom climb or climb with a steady speed, be it quickly or steeply, you should use the stick to start leveling off before you reach the new altitude to prevent overshooting it. You'll also need to throttle back to resume your desired cruise speed. If the climb is long enough to warrant using trim (to relieve pressure on the stick and hold the climb steady), be sure to trim the nose back down for cruise. The reason you need stick control in all cases is explained more closely in section refssec:phugoids on phugoid oscillations.

5.3.1 The power curve

5.3.2 Examples

5.4 Takeoff

Under certain circumstances, taking off is the easiest thing that there is to do in an airplane. Let's get started. Your commander has ordered you to get out and try some basic flight maneuvers. It's a still and sunny day and the long, paved runway shimmers outside the windscreen. The engine is started up and warm, and you've just had breakfast with coffee and are feeling good. You've completed your pre-flight checklist, checked all your flight surfaces, and oriented yourself on the runway. There are no obstacles around such as trees or raises in elevation. Now what do you have to do? Give it throttle, build up speed, use the rudder to keep yourself centered, and once an acceptable ground speed is reached, pull back on the stick a little to bring the plane into a gentle climb. That's it. Well, almost. It wouldn't do to have too short of a section on such an important and thrilling topic as takeoff now, would it?

5.4.1 The roll-out

Let's back up to where you were sitting on the runway and cleared to proceed. Unless you need to get as much speed in as short a distance as possible—say you are on a short strip or have a hill facing you—you can release the brakes and start applying power. Start the plane rolling by smoothly increasing the throttle. At a certain engine power the plane starts to roll out, and this is different for different aircraft. Once rolling, continue bringing the throttle control over several seconds to full throttle.

As you advance the throttle, you will probably notice that your plane doesn't want to roll straight ahead. The "side-to-side" yawing movement you've come to learn is collectively called ground looping, and is principally due to helical propwash (and, at the point where the plane's tail raises, gyroscopic precession.[6]) We won't study why this happens, but smoothly advancing the throttle greatly helps to reduce ground looping. However, it will happen, and the answer to this problem is the same as

[6]P-factor is negligible even in taildraggers.

the answer to most yaw problems: rudder. The same problem occurs during a landing roll-out, and the same procedure applies to correct it. To go straight you need to hold a certain amount of rudder. The faster you go, the more rudder authority you have and less you need to hold the rudder down. Now if the plane starts heading too far to one side, use more. Just make sure you don't overcorrect; you need to use lots of rudder on the ground, but if you do it too long you'll have the same problem in a new direction. Learn to anticipate what is going to happen.

After a stretch the plane really starts picking up speed. Once you reach a certain speed, maybe around 100 kph, the wings produce enough lift to bring the tail up[7]—we clever pilots notice this because the nose comes down. In some planes, such as the Bf 109 and the I-16, you want to get the tail up as early as possible by pushing forward on the stick as you begin to roll out. Don't forget to relax that forward pressure as you pick up speed and the tail will stay up on its own. Before too long, the plane will have reached a speed, typically around 160–180 kph, at which it can sustain its weight at a certain angle of attack [8] once the nose is brought up slightly. How long does this take, then? Until it's ready, and not before—learn the airspeed that has to be reached before you can pull back on the stick.

5.4.2 Lift off and initiating a climb

Taking off is little other than initiating a climb from level flight, so expect to apply the stuff we learned in the last section about climbing. We've already covered the first task of taxiing down the runway at high power to build up airspeed beyond what will allow you to start climbing. It is imperative to understand what a critical role airspeed plays. In takeoff you will in practice pull back a very small amount on the stick to make the slight transition from ground airspeed to a climbing attitude. In theory once you have reached takeoff speed a properly trimmed airplane will take itself off, but usually you will want to help it with slight backpressure. What you do not want to do is initiate a zoom climb! You can only successfully zoom climb when you have excess airspeed, and usually there is precious little of that just after takeoff. If you pull back too far on the stick you are in danger of running out of airspeed, stalling and finding yourself unable to recover before you return to your original altitude—the ground.

[7] You P-39 jocks just pretend you didn't read that.

[8] about twelve degrees' worth [4]

Unless you are in a powerful and light fighter, after initially getting off the ground it is good practice to accelerate to a good climbing airspeed somewhere in the area of V_y before you begin climbing further. The angle of attack corresponding to this airspeed will keep the airplane at a good climbing speed and allow the excess engine power to be translated into gained altitude. The aircraft in IL-2 are more or less trimmed when you start a flight session to maintain a good climbing speed, so if you don't retrim you need little stick input to get the right speed once you have achieved it and are in the climb. Many inexperienced pilots want to just get up in the air as fast as they can after taking off and keep their nose too high. Even if they are not as low as stall speed and are climbing, their high attitude keeps the airspeed down and they're on the front side of the power curve. Allow your airspeed to build up. The only exception is when you need a high climb angle to clear any obstacles.

5.4.3 Use of flaps

Now all of you Sturmovik and Stuka pilots pay careful attention: load factor has to be considered here.

5.5 Yaw

Because your aircraft is moving through the air, it is possible for it to point in a different direction than it goes. The job of the rudder is to minimize that difference. The difference is described by the slip angle, and it has a big role to play in the efficient and safe operation of your aircraft. It also plays a big role in your comfort, because being pushed from side to side is not always pleasant. Although you unfortunately don't have this to worry about in *IL-2*, it can become pretty inconvenient to have your head misaligned with the gunsight.

Yaw is an often overlooked axis of flight. You will have a hard time maintaining your energy during turns without managing your yaw axis. Keep an eye out in future discussion for descriptions of the role it plays in turning and various combat maneuvers.

5.6 Level flight

Level flight is where you are flying straight ahead, without gaining or losing altitude. Achieving and maintaining perfectly level flight is one of the more difficult tasks to undertake, even in a simulator where you don't have to deal with updrafts, and where typically there is no turbulence or wind at all. The key of course is the proper setting of trim and throttle. Set the trim to control angle of attack and thus airspeed, and use the power (throttle and propeller setting) for rate of climb. Once you have settled in you will have to keep movement about all three axes in equilibrium (for more on settling in, see again section 9.1.2 on phugoid oscillations).

If you have settled into level flight at a predetermined throttle and propeller setting (usually measured by manifold pressure and rpm) that are optimal for conserving fuel for a given altitude, you are at cruise speed. See section 9.3 for more details.

5.7 Turning

Getting the aircraft to turn is easy; getting it to turn efficiently requires some thought. It's the efficiency that's going to keep your six free of lead during combat. Because of the freedom of movement of an airplane there are many ways to turn. Combat maneuvers mostly consist of turning in a controlled and well-timed manner relative to another aircraft or group of aircraft. Specific turns for combat are covered in chapter 7. What we want to cover here are some turning basics and how to turn efficiently.

We could say that there are three categories of turns: horizontal, vertical, and some combination of the two. Horizontal turns are generally more familiar and the most commonly used in general. The vertical component of a turn is quite often very useful in combat, and only in certain fighting styles do you need to go purely vertical, so most of the time in combat we combine the two. We don't want to give you the wrong impression—combat is not all about turning! However, it is a very important factor and there is plenty to read about it later on. Let's get started with horizontal turns.

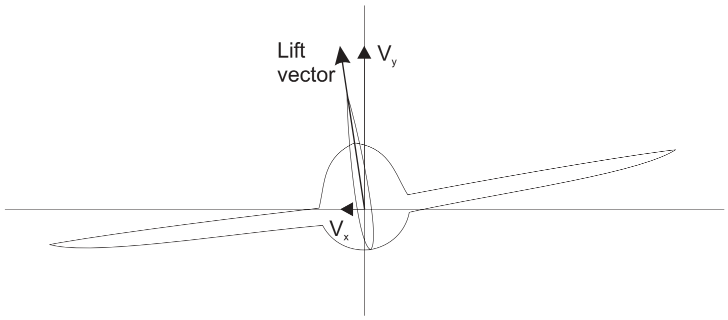

Figure 5.1: With the wings banked, the lift vector receives a horizontal component at the cost of some of the original vertical component. The resulting slip causes the tail to yaw, which changes the planes direction and begins a turn.

5.7.1 Horizontal turns and coordination

Your airplane turns the same way it climbs: through the lift vector. You can picture the lift as pointing straight up from the wings, so in level flight the lift vector only points straight up. Manipulating the ailerons causes a higher lift in one wing than the other so that the wings roll to one side. The pilot rolls the wings to a bank angle (or bank attitude) and hold it there.[9]

In this banked position, the lift vector is no longer only pointing only vertically and counteracting gravity, it also now has a horizontal component as well. This horizontal component of the lift brings the airplane out of a straight flight path by pushing the airplane to the side, in the direction of the horizontal component of lift, as depicted in figure 19. Now the aircraft is headed both straight ahead and to the left. This motion of the airplane being pushed/pulled to the side is called slip. As the airplane starts moving to the side (slipping), the vertical stabilizer receives its own angle of attack, so that there is a force acting on it. This force causes the airplane to yaw into a new equilibrium (I am still confused on the yaw and slip in an uncoordinated vs. coordinated turn), in which the airplane has a continually changing direction in the horizontal plane. The airplane will move along the path of a circle. You can visualize this process with the moving figures provided at [8].

So what control inputs are needed if any in all of this? As it turns

[9] In a real airplane you need very little aileron input to hold the bank angle. In *IL-2*, you have to hold aileron input to maintain a bank. This is a known issue in the flight model.

out, if you only use the ailerons to bank the plane, the plane will turn as described, but it will not point in the direction it is going. In other words, the plane will slip while in the turn. In a real airplane, you can feel this because you will be pushed to one side of the cabin. In *IL-2*, you will notice a head movement to one side in hard turns (*verify the amount of head movement in shallow but uncoordinated vs. coordinated turns*). The way to avoid this is to coordinate the turn by input with the rudder. By applying the right amount of rudder in the direction of the turn you will line up the aircraft fuselage with the direction of the turn. As you move the ailerons to bank the plane, apply rudder with the ailerons to coordinate the turn. In *IL-2* you don't need very much rudder input for this (it is understated). You can use the turn and slip indicator to judge how much rudder you need to coordinate—the ball should stay in the middle. If you are in a left-hand turn and don't use rudder, the ball will move to the left. If you use some left rudder, the ball will stay in the middle (actually you need varying amounts of rudder during the transition, but don't worry about that). If you use too much rudder, the ball will move to the right. The rule of thumb is to "step on the ball" to keep it in the middle.

> To coordinate a turn, apply rudder in the direction of the turn: step on the ball.

In fact we have been withholding information from you. Remember that in the bank the lift component gets divided between the vertical and the horizontal? If the lift was exactly enough to counter the airplane's weight in the turn and some of that lift is shifted to the horizontal, then the weight will be greater than the lift in the vertical. That means that the airplane will want to start accelerating downward. To maintain your altitude, you will have to provide enough backpressure to increase the angle of attack. This will increase the lift so that the vertical component of lift matches weight again, and also reduces the airspeed.

The circle that the airplane follows in the turn has a radius. For any airplane, the radius of the turn is determined only by the speed of the airplane and the bank angle. [9] etc. etc. etc.

Now that was a lot of explaining, but it is important that you get the idea that all of the axes of movement are involved in a turn. If you are thinking ahead you will realize that this explanation has its limits. Once you take the bank attitude beyond 45°, the lift component becomes largely horizontal, and you can control the

5.7.2 The vertical component

5.7.3 Efficiency

Turning radius vs. turn rate: [10]

5.8 Landing

Outside of combat, landing your aircraft is the most challenging and exciting procedure you are called to perform. There's nothing more beautiful than a good landing. To make a safe, proper landing, especially under non-ideal circumstances, requires a lot of concentration, even when you know exactly what you're doing.

The landing procedure starts with an approach. You will have a certain altitude and airspeed, and you will headed in a certain direction relative to the landing area. There are several different kinds of approaches. For now we are only going to concern ourselves with a straight-in approach to a landing strip. In this approach, you are going to establish what is called a glide slope, and maintain this glide almost until you are on the ground. The most difficult aspect of this kind of approach—and perhaps of any standard landing procedure at all—is judging where you are relative to the intended glide slope.

High command has deemed that smoking craters are in no short supply, so this section on landing has top priority to be finished.

5.9 Take her for a spin

Actually, don't! Spins develop at least one wing is in a stall, and because of horizontal rotation the two wings are at different angles of attack [4]. The aircraft is in a rotational motion that is very stable due to the centrifugal force. Think of a falling whirlybird.[10] They're very dangerous, so don't mess with them.

[10] A samara, as of the elm and maple. It's a leaf that has a wing with a seed at one end [4].

5.9.1 Preventing spins

How far you can push an aircraft before it stalls and snaps into a spin really depends on the aircraft's flight characteristics. Some, such as the IL-2, are impossible to spin. Others require a fair amount of care. The P-39 with its mid-engine placement is a notorious example. The key to preventing a spin is to prevent a stall, since a spin starts out with a stall. The easiest way to avoid a spin is thus to avoid a stall, and we already know how to do that: stay below a critical angle of attack. Theoretically then, you will never need to worry about spins, because you are going to behave and not push your airplane into a stall. Experience says that pilots starting out in *IL-2* are not only going to stall—a lot—but they are going to do a fair amount of spinning too, and use up at least a few dozen virtual lives in the process.

5.9.2 Types of spins

Since the voice of experience says you are going to end up in a spin at some point, it is important to distinguish between three main modes of spins: "normal," flat and inverted spins.

A normal spin. . .

A flat spin. . .

An inverted spin is obviously a spin in which the airplane is upside down. They are particularly dangerous, because they have to first be converted into a normal spin before they can be recovered from, so even more precious altitude is lost before recovery.

5.9.3 Getting out of spins

The general thing to do to get out of a spin is to oppose the direction of spin and to unstall the stalled wing. The challenge is to do this before you lose too much altitude, whether your criterion be minimizing lost energy in combat or avoiding the ground. Be warned: each aircraft has its own spin characteristic. In most aircraft, the basic technique is as follows:

- Cut throttle all the way back to idle.
- Center the stick. Whatever you do, don't pull back or give any aileron input, because this only makes things worse.
- Give full rudder in the direction opposite of spin.

- Move the stick quickly to get a zero angle of attack.
- Once the spin has stopped and both wings are unstalled, keep the nose below the horizon and apply full throttle.
- Once you have enough airspeed for stable flight, slowly bring the aircraft out of its dive.

Normal spin recovery procedures tend to only make an inverted spin worse.

If all else fails, leave yourself enough altitude to exit stage right: see section 6.6.

CHAPTER 6

Combat fundamentals

The objective is to kill the bandit. That's it. Pure and simple. That, and stay alive in the process. So, do what you have to . . . But kill the bandit dead. Anything else is rubbish.

—Andy Bush

It is not until you are shaking down the runway at 110 kph that you realize for the first time that this morning's haze might make lining up the the approach difficult when you return later. If you return; only one pilot of yesterday morning's patrol Zveno had that good fortune. Such habitual thoughts don't distract you very long, and as your well-weathered Ilyushin-2 passes 210 kph you initiate a lazy turn toward your next waypoint over Orel. Forests and rivers shrouded in this haze slip beneath your wings on the twenty-minute hop to your target, and by now it doesn't take so much concentration to stay in formation. You use the time between instrument checks to try and remember faces of lost comrades over the last two months of your war—just how many have there been? You are jerked out of your thoughts by the sound of a sudden leap in the engines of the accompanying I-153s. Seconds later your number two calls out: "Вражеские истребители, слева

> выше!"[1] *Of course you have been maintaining a sweeping gaze to spot enemy fighters, but you have also taken your time squinting at the road running alongside that lake—what's its name again—searching for vehicles. Wake up! We're still three clicks from the target...*

Air combat in the second World War was terrifying, demanding, boring and thrilling, and required a hard life. Most of us are perfectly content to simulate the more "glorious" aspects; some do it more seriously, with an eye on historical accuracy and immersion, some more lightly, with a lust for shooting something down, and we all are likely to enjoy a wide variety of experiences. All the same, regardless of whether you are hitting autopilot and 8x speed to get to the battle in an offline campaign or flying with no view assistance into an online coop with human opponents, the basics of combat are the same. As you read through this chapter, keep in mind that at some point just about every topic discussed is going to become very relevant to keeping you in the sky.

6.1 Gunnery

> *I like to show off my shooting prowess to the enemy pilots by carefully hitting insects that are flying near their aircraft. Then, if I really want to instill the fear of God in them, I begin chipping away all the paint on their wings. Highly impressed, the enemy then tries to duplicate my feat. However, the attempt is clumsy and they end up shooting off one of my wings. As my chute pops open I wave and laugh at the clumsy enemy as he flies back to his base in shame. And so, I continue to rule the skies over Russia.*
>
> *—Letterboy1*

Marksmanship is one of the most valuable skills a combat pilot can have, and especially fighter pilots. Warplanes are essentially intended to be nothing other than mobile weapons platforms. Cleverly maneuvering your plane into a firing solution on your enemy does nothing for you if you are in no danger of hitting him. As a WWII combat pilot, gunnery is very probably the first skill that you ought to develop after basic

[1] Enemy fighters, 10 o'clock high!

flight. You are not likely to be as skilled as Letterboy1 at first, so we'll have to set our goals a little lower and content ourselves with making holes in enemy aircraft.

6.1.1 Convergence

Just like every other unpowered object in a gravitational field, bullets[2] don't travel in a straight path.[3] Instead, the path they follow is very close to a parabola—think of that famous arch in St. Louis. The bullet path is much more stretched out, but you get the idea: they go away from you very quickly, but they also fall towards earth.

What's more, many of the planes you will fight with have guns in the wings. Not only does this reduce the maneuverability of the plane, it creates a sizeable distance between the more or less parallel paths of the bullets as they leave your plane. That's not so great if you think about it, because you are hoping that they'll all end up in the same place on your target.

The answer to these worrying problems is to set the paths of the bullets to converge at a distance in front of the plane that you expect the target to be. This is illustrated in figure 23.

6.1.2 Gun reticle

The gun sight in most planes in *IL-2 Sturmovik* use a reflector sight, or reticle, which is your main method of estimating where your shells will go, like the crosshairs in a rifle scope. This is pretty intuitive, so we'll try to just "point out" a few noteworthy things. First of all, the reticle itself is a piece of glass slanted backward towards you. The yellow pattern you see on it is reflected light that is being projected from below. The main advantage of this system is that as your head moves a bit out of position with the glass plate and the target, the reflected light tells you this (is this true?). A further historical advantage is that this system made it easier to adjust the sights to point to the convergence set for the guns. There are also either concentric rings or tick marks on the crosshairs. These are meant to be used to help line up deflection shots, which you can read about below.

[2] You don't mind if I just refer to all calibers of fired projectiles as bullets, do you? Good, thanks.

[3] Unless they're going straight down.

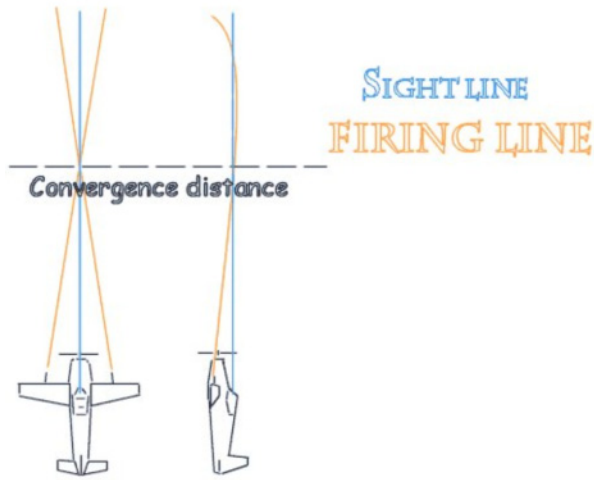

Figure 6.1: The paths of the projectiles are converging towards each other horizontally from the wings or to a certain height from below the pilot's line of sight. In either case this doesn't happen until a certain distance from the plane, which can be adjusted.

There's one more thing about that reticle that you've surely noticed. In many of these craft they were positioned so as to not line up with the pilot's normal line of sight. That means that the pilot had to move his head a bit to see the target through the gun sight. In *IL-2*, you can switch between a normal view and the gun-sight view with the key combination `Shift+F1`.

6.1.3 Machine guns and cannons

What's the big deal, anyway? After all, the difference between 7.62 mm and 37 mm is only a little more than an inch, right? It turns out that size does matter, but also velocity and firing rate. What you really ought to know is that machine guns are effective for finding targets, and while they can do some damage, it is the cannon fire that is usually going to bring planes down. Machine-gun rounds are lighter and are fired much faster in comparison to cannon rounds, and there are often lots more of them loaded.

Tracers?

6.1.4 Angle-off shooting

There are pretty much two situations in which you can point your gun sight straight at a target and expect to hit it: in head-on passes and from the six-o'clock position of the targeted aircraft. If you'd like to hit the target right where your crosshairs are pointing, then the target had better be at a distance where your shells will all converge. Angle-off is just a term used to say that the fuselage of your plane and that of your target have a small angle between them. Think of a narrow cone extending behind or in front of an airplane. Other airplanes in that cone are in an angle-off position.

The reason it's so much easier to hit the other planes from an angle-off position is that bullets don't travel in a straight line, as already discussed in convergence.

6.1.5 Deflection shooting

Give more angle than you think is necessary. Don't clench the stick (rudder pedals might help a lot here since you won't have to twist the stick to coordinate the turn).

There is a set of wonderful articles [11] written by Andy Bush that will help you learn a lot more about gunnery.

6.2 Situational awareness

The absolute most valuable thing to a pilot is an understanding of his surroundings, including the condition of his own aircraft. This is true both in and out of combat, and a pilot is constantly gathering information about his situation. Not surprisingly, there are good ways to do this, and then there are better ways. You are surely aware by now that there is no small amount of information available. Obviously the various tidbits of information must also be given a priority, and the priority changes depending on how the situation develops. Beyond that, once the information has been gathered something has to be done with it.

You've known this all along, of course. It's intuitive. However, in combat things can get a little stressy, and considering beforehand what information to gather and practicing gathering it will help build up a little discipline. You want to train your mind to constantly be observing the information relevant to your situation. If you'd like to better appreciate the high level of awareness that combat pilots had, just read some of their combat reports. Among the more relevant aspects[4] of situational awareness in combat are:

- Altitude
- Airspeed
- Engine power setting
- Condition of the engine and general engine management
- Position of gear, flaps, radiator/cowl flaps, propeller pitch and other settings
- Damage to your aircraft and its impact on your capability to perform maneuvers
- Weather conditions and forecast conditions: the current and predicted visibility, direction and strength of wind, humidity, etc., as a function of altitude
- Position of the sun relative to you, your unit and the enemy
- Relative altitude and speed of nearby friendly and enemy aircraft and the location of other objects (such as clouds) with respect to your airplane
- Types of both enemy and friendly aircraft and the skill and state of mind of the pilots
- Strengths and weaknesses of enemy aircraft relative to your own
- Location of friendly and hostile surface units
- The location and heading of your aircraft, position relative to enemy lines, and land features that may be of help or hindrance
- Amount of fuel left, and how much required to return
- Whether the mission parameters have been fulfilled

It is a common mistake among those who innocently set themselves in the virtual combat cockpit to only consider a couple of these critical data, and almost certainly not at once. It is natural to concentrate primarily on the relative position of the enemy aircraft, and be preoccupied with worry about whose guns are pointing at who. The beginner might consider altitude at the beginning of the engagement, or airspeed when

[4] It is left to you to consider which may or may not be relevant in *IL-2* and to your particular mission.

there are no enemies close by to shoot at, and when a desperate getaway is in order.

With time you will learn to consider and process a lot of information at once, because it has become built-in routine. However, observation is only the first step on the road to victory. We have already mentioned that something has to be *done* with the information gathered. What has to happen between observing and acting on the information gathered?

The OODA cycle

After his experience in the Korean War, Col. John Boyd developed a now-famous theory involving a continual process he named the OODA time cycle (or loop):

observe yourself and the physical environment

orient yourself by making a mental image of the situation

decide based on all factors present in the orientation

act on your decision without hesitating

You are going through this time cycle, which is also referred to as the Boyd cycle, all the time whether you know it or not. All combat is time sensitive and as described by Col. Boyd, whoever can process this cycle more quickly than the opponent, or stay inside the enemy's OODA loop, will have a huge advantage and should emerge victorious. If you can process that loop faster, the enemy's observations and orientation will be slower and thus his decisions and actions will be increasingly ineffective as you get further inside his loop, keeping him on the defensive. Keeping a good OODA cycle is the foundation of situational awareness, and because situational awareness is so critical to success in aerial combat, you would do well to study this concept further. [12, 13, 14]

Since the key to success lies in your OODA loop being faster than the enemy's, you will want to train yourself to accurately and efficiently observe, instantly orient yourself to the new information, make lightning-fast decisions, and act without hesitation. If your goal is to become a superior fighter pilot, you might decide to find or set up a program to train yourself. In this guide we hope to provide you with information that will help make you more aware of what you need, but it is up to you to train.

6.3 Detection and closing

The OODA process teaches us that you have to be able to make observations and orient yourself faster than the enemy. On a larger and slower scale, you also want to detect the enemy and close on him before he does. You will go through the OODA cycle several times while doing this, but detection and closing are the first two steps in an engagement just like observation and orientation are the first two steps in the Boyd cycle. Detection of the enemy is a simple concept: see the other guy before he sees you. Closing involves maneuvering your aircraft to a position of advantage, nearly always above and often, if possible, behind the enemy.

Simple as that may be, there is a lot involved in this competition to spot the enemy first, and as much or more in maneuvering to an advantage.

6.4 View systems

icons (`mp_dotrange`), map, padlock, snap/pan, mouse, TrackIR, viewing frame rates

6.5 Navigation

Mission success is often critically dependent on your flight being able to reach the mission area in a timely fashion, at the right altitude and from a given direction. This is especially the case in bombing, intercept and ground attack missions. Furthermore, after the mission is over you will need to return to base, often abbreviated as RTB. All of this requires navigation skills.

There are various levels of navigation that can be engaged. The most obvious and easiest, which many people prefer to use, is to engage the autopilot. The autopilot will usually do a good job of carrying you in formation along the waypoints at the specified airspeed. If you are leading the formation your plane will follow the waypoints and your flight will follow you. If you are a wingman, your aircraft will follow the plane in front of you in formation. If you are not interested in saving the track (see section 10.6), then you can also speed up the time in flight to and from target by using time acceleration. (The `[` and `]` keys accelerate and decelerate time.) However, the autopilot will also fight for you and make bad decisions, so if you do use it consider disengaging it before you think you need to. Be aware that when you disengage the autopilot the controls suddenly relax and your plane may fall sharply out of formation.

The autopilot also shows a tendency to be unreliable. Many have experienced it flying you into the side of a hill, or abruptly performing a nosedive into the ground. If you are using it to save time, that's one thing. (Have you tried flying manually at 8x?) If you are using it for navigation, that's another. Either way, it's not very immersive and probably less fun. After all, you're in a flight simulator, why should you let the computer fly instead of yourself? In *IL-2* you are perfectly capable of navigating without the autopilot.

A second possibility is simply to use the in-flight map to follow the paths between waypoints, which are clearly marked. (If you have map icons enabled, this will also tell you where both friendly and enemy aircraft are. For full immersion, turn them off. Unfortunately, you can't turn your own aircraft icon off.) As soon as you pass through, or sometimes near, a waypoint you will see a line extending from your aircraft icon to the next waypoint. By following this line you will easily be able to navigate to the intended areas of your mission. It is important to recognize that your flight will also follow these waypoints, and that if you are flight leader you can command your flight to remain at a given waypoint or proceed to the next one. The map does not inform you at what altitude and airspeed the flight should be.

Many of the aircraft have a repeater compass that indicates the direction to the next waypoint. By aligning your heading with this direction you will be able to navigate to the next waypoint without needing to rely on your in-flight map. The repeater compass does not indicate how far you are from the next waypoint, but the closer you are to the waypoint, the further the needle will swing when small excursions are made from the correct heading.

A third possibility, which can be very demanding and satisfying, is to abandon both the autopilot and in-flight map and use visual flying rules (VFR). In this method you will compare the landscape with a map to locate your position and choose your heading. Since in *IL-2* you cannot turn off your own map icon, you might consider printing out a map of the area of operations. Example maps can be found at [15].

Here are some tips for VFR navigation. Always study the map in detail before a mission. (This is generally a good idea anyway.) Know where your base is relative to the front lines, and relative to the mission area. This way you at least know in which general direction to head to get back to base (north, east, southeast, *etc.*). Your map will show you where your target area (you may need to mark it beforehand) and base are located. After that, you can use rivers, patches of forest, lakes, cities, mountains, coastline and whatever else you find useful to determine your location. Rivers are usually plentiful, and specially shaped rivers are very helpful for confirming location. Don't be afraid to go off your guessed course to make sure you are in the location you think you are.

If you are on the way home and really can't make out where you are, try using the radio to request a heading to base. Be prepared to listen carefully to the reply in German or Russian unless you haven't disabled the subtitles (see section 11.1.2) or you have a language pack you understand installed. For full immersion, always make sure you get back across enemy lines. Then if you run out of fuel or your plane is hopelessly damaged and the engine quits or is about to explode you can crash land or bail.

If your cockpit is completely shot up or you are in a cockpit that has an obstructed view of the compass, you will have to find an alternative heading indicator. There are at least two possibilities here. One is the speed bar, located in the lower left-hand side of the screen in the form of a red letters and numbers. This can be be assigned a key (see section 10.2) and toggled on and off. On the speed bar there is the entry `HDG`, which provides the compass heading in degrees. Another alternative is the sun. During day missions this is a handy reference and hard to miss. Of course at high noon it gets difficult, even in western Russia. The most

This visual navigation is not only challenging, it is absolutely a heap of fun and very satisfying after a mission. Don't forget to keep an eye out for enemy planes while navigating.

If you find you like navigating, you can create a mission for yourself to fly around and learn the area better. For instance, if you are in the L'vov map, you can fly around until you are able to recognize towns and special rivers. (There are more river branches in L'vov than probably anywhere else on earth.) This can really add to immersion.

But whatever you do, don't count on your autopilot to get you home, unless you like repeating missions and losing results. At best you can engage the autopilot for about 10–20 seconds, until it gets you on course for home, then take the controls again. Keep in mind the autopilot will set the course for the next waypoint, not necessarily the base.

6.6 Emergency procedures

Flak. Twenty-millimeter cannon. An unusable airframe. A dead or burning engine. An unrecoverable spin. No fuel. All reasons for you to think critically about how to get home safely. Sometimes you can set her down, sometimes you have to hit the silk. How do you know when to do what?

6.6.1 Bailing out

You hope you never have to do it, but it happened to the best, and often more than once. Sometimes your baby is not salvagable, and you've got to bail. The command for this in *IL-2* is the key combination `Ctrl+E`. After a delay the pilot will open the canopy and jump from the plane.

6.6.2 Forced landings

6.7 How to get started

This section will lay out some commonly given hints for the new combat pilot about how to get started with gunnery and maneuvering.

CHAPTER 7

Combat maneuvers

You wouldn't talk very long with experienced combat pilots before you start to get the impression that combat is not simply a sequence of fancy maneuvers. However,

7.1 Energy fighting

7.2 Maneuverability

7.2.1 Speed

7.2.2 Altitude

7.2.3 The plane

Wing loading, weight distribution, loadout and other issues, not an overly deep discussion though.

7.2.4 Corner speed

7.2.5 Use of secondary control surfaces

7.3 Basic maneuvers

7.3.1 Break

7.3.2 (Aileron) Roll

7.3.3 Barrel roll

7.3.4 Chandelles and the combat turn

7.3.5 Yo-yos

7.3.6 Loops

7.4 Advanced maneuvers

7.4.1 Scissors

The scissors is a purely defensive move. It's not easy, and requires a lot of information about relative position to the attacker and a good visualization of the situation.

There is an excellent article written by—you're not going to believe this—Andy Bush [16]. You'll definitely want to check that article out to get all of that sound advice.

7.4.2 Hammerhead

Slightly different from a wingover (how?).

7.4.3 Spiral climb

The difficulty is in learning the timing.

7.4.4 Snap roll

CHAPTER 8

Ground pounding and fighter tactics

8.1 Ground attack

Ground attack is the pinpoint attack of targets on the battlefield. In principle, any aeroplane carrying a weapon load can be used for ground attack. In the First World War, fighter pilots soon realized their ground attack potential. They adapted their fighters by adding a small bomb load, supplementing their machine guns for the attack of enemy troops, artillery, trenches and transport columns.

The idea was successful, and the fighter-bomber was extensively used in the Second World War by all major air forces. Planes such as the FW 190 had variations purpose built for the ground attack role, but any fighter could be used for ground attack.

An alternative approach (?) to ground attack was the use of the light bomber, the Ju 87 Stuka dive bomber being the most famous example. The Stuka was a key component of the early success of the German Blitzkrieg in 1940.

The Soviets produced the unique IL-2, a specialist ground attack plane which carried a diverse range of bombs, rockets and guns. This heavily armored aircraft was the terror of the German tank divisions on the Eastern Front.

8.1.1 Desirable aircraft features

Good armor and robustness Statistically, ground attack is one of the most perilous activities a combat pilot can undertake. The principal hazard is the flak: Ground attack requires the pilot to get low and close to targets often well defended by Anti Aircraft artillery. It is likely that a ground attack aircraft will be hit by the AA barrage, so a plane structure and engine that can sustain damage and still function are advantageous, and ample armor plating of important areas (principally the pilot and the engine) is typically used.

Wide variety of payloads Rockets with various warheads, bombs of various types, and large caliber weapons (typically 20 mm or more) can all be useful, depending on the nature of the target, in ground attack. The ability to carry considerable weight, and adaptability to different loadouts, are therefore advantageous.

Speed Spending as little time as possible in a ground attack plane in the flak zone tends to keep pilots healthier. Speed also assists in reaching and leaving the target area unmolested by enemy fighters. Don't make yourself an easy target.

Stability Ground attack targets are usually small, and since they are slow and thus static relative to your aircraft, closing speed is high. Therefore the ability to fly a precise and steady flight path towards the target is essential. Launching rockets or firing high-caliber weapons can shake a plane, so a stable gun platform will increase the likelihood of getting hits. Using trim correctly will help you make the most of the stability of your plane.

8.1.2 Delivering the payload

Level bombing

Without a specialist bomb sight (these are available in *Forgotten Battles*), even remotely accurate level bombing takes a good deal of practice. Once released, your bombs will travel forward at the same speed as your plane (minus loss of speed from drag), so you should aim to be directly over your target at the time of impact. You have to get as low as possible to achieve accuracy with level bombing. The lower you are, the later you leave bomb release. Of course since you are over the target at time of impact it is important that you have a bomb delay of at least three seconds to give you time to escape. If your target is moving, this means that you will have to aim for a point well in front of your target.

As an example, suppose you are flying at 10 meters above the ground (rooftop height) with an airspeed of 300 kph, or 83 m/s. Your bombs will take approximately one second to reach the ground. You should therefore release them when you are 83 meters from your desired impact point—that annoying tank that just sniped your front lines. At such a low height you can actually lob the bomb into the side of large targets such as ships and aircraft hangars. Use the track record facility to review your accuracy and learn the correct timing. If you make your bomb runs at a standard speed, this training will be even more profitable.

Dive bombing

The time of bomb release is critical to level bombing accuracy. However, if you dive in your attack, the criticality of timing is reduced, and this is the idea behind the specially designed dive bomber types. The ideal in dive bombing is a ninety-degree (*i.e.*, vertical) dive. In this case, as long as you are directly over the target and descending vertically downwards, when you release your bombs, the bomb cannot do anything else but fall directly onto it (unless the wind has something to say about it). It is desirable to delay bomb release as you will be able to line up more precisely on your target the closer you dive to it. In classic dive bombing, your dive should be between 75–90°. The further off vertical you are, the more you will have to compensate for your dive angle.

Though you can use dive bombing techniques in any bomb-equipped plane in *IL-2*, the Stuka is specially designed for it, and we will discuss Stuka technique in some detail. Dive bombing is, however, broadly the same in any plane. You should begin your dive at least 1300 m above target level. The higher you begin, the longer you will have to adjust your line-up on the target. Ideally you will be directly over your target when you begin your dive. Acquire your target through the window in the floor of your Stuka cockpit. Let the target disappear past the rear of the floor window, so that it is directly under you. At this point, roll onto your back, cut the throttle, apply the dive brakes and slowly and smoothly pull the nose down to line up on the target. Practice this procedure with a bomb load until you can do it quickly and automatically. The air brakes should give you plenty of time to line up, so keep your adjustments in the dive small. It is very easy to over correct. First, roll so that the target is directly ahead of you. Then use small amounts of elevator so that you are aiming directly at the target. As you get closer, you can fine-tune your aim by repeating this procedure.

In reality the Stuka had a sophisticated dive bombing sight, but in *IL-2* you have to use the gunsight as your reference point, as was the case in fighters adapted for dive-bombing. Note that your line of flight is not exactly the same as the line of fire indicated by your gunsight. You will find that as you dive, the point on the ground you are heading towards will be above your gunsight. Test this by watching carefully what happens as you dive without altering your dive angle by adjusting the controls. The terrain beyond the point at which you are diving will appear to recede and move up the screen, and conversely the terrain on your side of the aiming point will appear to move down the screen, disappearing under the nose of your plane. The still point from which the terrain appears to expand is the true point towards which you are flying. You can use the top of the reflector gunsight glass as a rough guide for my aiming point in a dive.

As you near the target, the difference between the point under your gunsight pipper and your true aiming point will decrease. This means that you will see your target slowly drift down towards, then through, your gunsight. Let this happen naturally: keep the angle of the dive constant. Make sure that when you release your bombs, you are descending along a dead-straight line. Any yaw or pitch will wreck your aim. When the altitude warning horn sounds, the gunsight should be approximately on the target. If you are descending vertically, simply release your bombs, disengage the dive brakes and pull out. If, however, you are diving at an angle less than 90°, your bombs will undershoot unless you compensate for the effect of gravity pulling the bombs down and away from the straight line of your dive. This compensation is known as the bombing angle—you begin to pull out before bomb release, which will correct for the lag caused by gravity. The amount of rotation to allow before bomb release will depend on the speed of dive, the height of the release point (the lower the release point, the smaller the required correction) and dive angle (the further off vertical, the larger the required correction). It will be readily appreciated that the vertical dive is a considerable help to accuracy, but failing that, training to dive at a set angle and releasing at a set altitude makes accurate bombing easier. Without controlling the variables in this way, it is very difficult to calculate the bombing angle for a given dive. A commonly used method is to release the bombs when the target begins to disappear under the nose of the aircraft during your pullout.

In *IL-2* the Stuka will automatically pull out the moment you release the bombs. In *Forgotten Battles*, you will need to manually disengage the airbrake as well. Be careful that you do not pull out too late and follow your bombs into the ground, particularly if you are not using a Stuka and do not have automatic pullout. Try trimming your fighter-bomber tail heavy and push your stick forward during the dive to stay straight: this will make your pullout more rapid and reliable, even if you black out.

Here is a list of dive-bombing tips:

- It's worth setting up your controls especially for the Stuka—for instance, map bomb release and the airbrake to joystick buttons. (In *Forgotten Battles*, if you use buttons next to each other, it's easy to press both at once, thus giving you simultaneous bomb release and pullout.)

- Use the sideways snap view (preferably with your joystick hat-button) to check your dive angle with the windscreen angle markings: the line in parallel with the horizon indicates your dive angle in degrees. Remember, the shallower your dive, the more you will have to aim beyond your target to compensate for gravity lag.

- When beginning dive-bomb training, use the `[` key to slow the game down. This gives you more time to line up and think about the bombing angle you will need.

- Fighters do not have the advantage of dive brakes, so in them try using flaps to slow and steady your dive. In any case you will want to throttle back. Certain flap settings might disturb your trim, making a steady dive difficult or impossible, or your flaps might jam if you dive too quickly, so don't start the dive with a high speed. Experiment to find what works for a particular aircraft.

- This discussion has assumed a stationary target and no wind. If your target is moving you will have to offset your aiming point accordingly, and if there is wind you will also need to anticipate the drift of your own aircraft.

Rockets

You have no option to launch all rockets simultaneously in *IL-2*, and the delay between rocket launches means that ripple firing is probably not a strong option. Fire one or two salvos of rockets, exit, observe the effects of your attack, and re-engage as appropriate, even if that means following your cursing flight leader.

Just as with bullets, gravity causes the trajectory of rockets to drop: beginners at rocket attack often find their rockets falling short, so learn to aim beyond the target. The further from your target you are when you launch your rockets, the more you will have to compensate for gravity, so get as close as you can without taking damage from the rocket burst yourself. In a close-in, horizontal or shallow-dive rocket attack, try aiming at the roof of your target, or just above it. Alternatively, you can choose a steep dive to lessen the effect, just as in dive bombing.

Torpedo attack

IL-2 is quite forgiving in all respects of torpedo launch. Unlike a real ship, which would likely maneuver to frustrate your aiming, your target will maintain a steady speed and course, and torpedoes nearly always run successfully as long as you fly straight, as low as you can and at a steady speed.[1] Approach the target at a right angle to the course of your target with your flight path intersecting the ship's direction ahead of the ship. The further away you release your torpedo, the further ahead of the target you will need to release your torpedo. As is usually the case in ground attack, firing from as close as possible is advantageous. You are more likely to give too little offset than too much—ships are deceptively speedy.

Skip bombing

You can also try your hand at releasing heavy bombs into ships. Conventional dive bombing or mast height bombing runs are options, but you can also use skip bombing. If you fly as low as possible when releasing your bomb, it strikes the water surface quite obliquely and will bounce a considerable distance. The technique here is similar to a classic torpedo run, except that less offset is required as the bouncing bomb

[1] In fact, torpedoes seem to not care about physics in *IL-2*, and will travel happily through the water regardless of the release height, angle or speed.

will travel faster through the air after skipping than a torpedo through water. When the bomb strikes the hull of the ship it will be arrested and begin sinking. Set your bomb delay to zero, so the bomb explodes as close to the ship as possible.

8.1.3 Exiting

Once you have made your attack you can concentrate on surviving your exit from the target area. Anti-aircraft fire is probably much more accurate than was really the case, and this is deliberate. Fewer guns are needed to create a realistically dangerous flak screen, thus easing the load on the game engine. This means that AA guns needed to be treated with a great deal of respect.

The preferable exit method is often to stay low and to get out as fast as you possibly can. You should plan your exit before you start your attack run. Look for villages, forests or high ground that you can duck behind to screen you from any anti-aircraft fire. Without this extra cover you will be vulnerable to fire regardless of how low you fly. Do not stay on a continuous course—you should jink to throw off the AA. The artificial intelligence is very accurate, but unimaginative: for instance, it will not anticipate your evasive maneuvers or learn from your tactics as human AA gunners might. Keep your evasive maneuvers small to maintain your speed. Small balanced turns and/or skids will usually keep you out of AA sights. At the end of the day though, if there is no significant cover to use around the target, escape is something of a lottery. When you are so low, your chances of bailing out successfully are minimal to zero. Use your speed to zoom climb before bailing if you think you are critically hit and cannot escape or successfully crash land.

An alternative to the low exit is to climb hard following an attack. This was a commonly used tactic in the second World War. Low-level flying is inherently dangerous, and regaining height quickly lessens your vulnerability to enemy aircraft. In the real world, putting vertical and horizontal distance between you and the anti-aircraft guns also makes the firing solution harder to find than if you are flying in the vertical plane at a constant speed. Unfortunately for us this tactic is less useful in the game—computers are much better at this kind of deflection shooting problem than human gunners. A major real-world benefit to the high exit was that climbing into the sun, through haze, or into cloud, all successful ways of throwing off anti-aircraft fire. Again, none of these factors will impede the accuracy of the AAA in the game: the only environmental element you can use to your advantage is physical obstruction between you and the bullets firing at you. Fire can even hit you if there is no line of sight between you and the gun firing—at long range, anti-aircraft will lob its fire high, over intervening obstacles, and down onto you. Don't assume you're safe once you can't see the defensive batteries.

8.1.4 Targets

It is important to use an appropriate weapon for a given target. The main types of target you will encounter, listed in roughly ascending order of toughness, are anti-aircraft guns, soft-skinned vehicles, parked aircraft, boats, armored vehicles, buildings and structures (in *IL-2* this category is essentially confined to bridges) and ships.

The following targets are listed beginning with the weakest:

Editor's note: the remainder of this section has not yet been edited. Sorry mikeyg007.

Anti Aircraft guns AA, also known as AAA (anti-aircraft artillery) or Flak. Anti Aircraft guns, whether heavy or light flak can be destroyed easily with almost any weapon from cannon upwards: a short burst of cannon fire is sufficient. Of course, it has the unpleasant habit of firing back, and techniques for surviving flak are dealt with later in this chapter. When you are flying down the barrel of flak, jinking is not an option: you must stay absolutely steady in your approach. The section on dealing with Flak below will help you to minimise exposure to this unpleasant situation.

Soft Skinned vehicles Soft skinned vehicles are those without significant armor. The most common soft skinned vehicles you will encounter are trucks, cars and motorcycle/sidecar combinations. A few rounds of accurate cannon fire will suffice to destroy soft skinned vehicles.

Parked or grounded aircraft Heavy cannon fire is a good weapon against planes on the ground, but a good deal of damage has to be inflicted to score a kill. When attacking a flying plane, disabling flying surfaces or engines will allow gravity to finish off your prey. Therefore weapons such as bombs and rockets are justified against planes—larger planes such as bombers demand heavier ordnance.

Boats and subs Rockets, medium bombs, sustained cannon fire, and, obviously, torpedoes will all sink boats and subs.

Armored vehicles and tanks Heavy cannon may be adequate against targets with light or medium armor such as half tracks. Your real headaches start when you have to face tanks. Tanks are one of the most historically important ground targets in the Il 2 theater, and one of the toughest nuts to crack in Il2.

Different armor strengths are accurately modeled for different makes of tank, but in practice it is difficult to distinguish different kinds of tank from the air so you will probably employ the same general technique. Tanks can be distinguished from soft skinned targets by the considerable amount of dust that surrounds them—an extra difficulty for the ground attack pilot. They typically travel in groups of four, in line astern. When travelling cross country they will often adopt a diamond pattern when an enemy pilot approaches, thus complicating your strafing pass. In this case, aim for either the leading or trailing tank.

Always attack tanks from behind, where the armor is weakest. Rockets and bombs are the weapons of choice against tanks. You will have to hit the target dead on to get a kill: Il 2 has an all or nothing damage model for ground targets. You cannot disable a tank by, for instance, causing it to throw a track.

The ability of tanks to hit attacking planes with their main armament is disconcerting: and generally acknowledged as unrealistic. A single hit by a tank's main armament will either disintegrate your plane or cause you to instantly explode. Either way, you are not likely to survive. Watch the turrets of tanks—if they have revolved to aim at you, and you are being cautious, consider breaking off the attack. Once you have attacked, change direction slightly, forcing the tanks to use deflection when shooting at you.

Buildings, structures and bridges Some structures are destructible in Il2, some are not. The only ones with tactical significance are bridges: an example of this is in the first mission in the Il 2 campaign, in which the German armour can be prevented from reaching the station you are defending by destroying the bridge. Use bombs to destroy bridges.

Ships Ships are very difficult targets to destroyyou are likely to have the most success with torpedoes.

8.1.5 Team tactics

If you are flying as part of a team, either human or AI, teamwork can substantially improve your chances of destroying ground targets and escaping successfully. If you are flying offline, be ruthless in using your AI wingmen: war is a tough business, after all. Order your AI planes to attack your target, and follow them in once the flak has locked onto them, giving you a clearer run. A common tactic was to send in flights to suppress Anti Aircraft Artillery before the main target was attacked—this is an ideal job for your accurate, nerveless, but unimaginative AI pilots. Specify AAA as their ground target while you stand off and observe results. If time, fuel and enemy fighter activity permits, keep repeating the order until the flak is subdued making the attack on the main target by yourself and any remaining wingmen more survivable.

If visibility is poor, you choose to fly over the target area to pick out your targets—for instance, to distinguish armoured from soft skinned vehicles. You can then use your high powered loadout (rockets and bombs) on the tougher targets, leaving soft skinned vehicles to be mopped up by machine gun or cannon fire. The weakness of this method is that AA will be alert and waiting when you re-approach your target for your attack proper. If flak is strong, there is a strong case for making hard and accurate attack and then departing immediately. If you adopt this prudent attitude, a simultaneous attack maximises your survival chances. It makes sense to bring the maximum ordnance to bear in the first pass, by having all planes in your flight attack simultaneously. A line abreast formation is ideal for this technique, which suits a widely distributed target such as an airfield. Another variation on simultaneous attack was the 'converging attack' of torpedo bombers, designed to trap an enemy ship in a converging circle of torpedoes and thus defeat its evading manoeuvres.

Sequential attack is in some circumstances your best bet. A transport column lends itself to a sequential attack by planes in a line astern formation. But perhaps the most famous variation of sequential attack is the carousel or Circle of death used by the IL-2. The AI in Il2 will sometime use this technique, so if you are following an AI flight leader watch out for your flight moving into line astern formation. Then simply follow the plane ahead of you. As each plane approaches the target it puts its nose down into dive of perhaps 45 degrees, and attacks with whatever weapons are available: rockets, bombs or guns. The plane then climbs back into the circle. This attack is typically maintained until ammunition is exhausted. The carousel is designed to keep the enemy under continuous attack (though the advantage of this in terms of shattering morale and suppressing enemy movement and effectiveness is less meaningful against AI targets). It does however have some use in dividing flak, as flak is forced to choose between three targets: one running up to the dive, one diving, and one climbing in its exit.

8.1.6 Summary

In order to be successful in ground attack in *IL-2* you need considerable practice, an awareness of the particular characteristics of each plane, and sustained concentration in all phases of the attack. If you invest this effort you will be rewarded with the satisfaction of destroyed targets on most of your ground attack missions. Good luck, and remember—the most important factor in any mission is not the number of kills obtained, but getting home in one piece!

8.2 Tactics

Wouldn't you just know that one the most important sections is not yet written? If you just can't wait, we can recommend [17].

8.3 Team tactics

8.3.1 Formation flying

8.3.2 Formations

CHAPTER 9

Advanced topics

There are some things that you just can't get around having to know about before you can understand the most basic aspects of flight. For example, you can't really study how to take off or land until you know about stalls and flaps. With energy, we're going straight to the heart of things. Before we go any further, however, a word to the disheartened: if you don't understand some of the concepts here—or just don't believe them—don't worry! Read on through them and absorb what you can. Then go fly some, and come back and read them again after you've had some exposure.

9.1 Angle of attack stability

Per the chapter in Denker, made practical for *IL-2*. Emphasis should be laid on teaching the reader how to maintain stable flight. This is especially important in light of gunnery. Make an example with track of approaching a bomber's six out of a climb doing it the right and wrong way?

9.1.1 Changing angle of attack

How to make smooth changes in airspeed and climb rates. Example of leveling off from a climb.

9.1.2 Phugoid oscillations

In earlier discussions about altering altitude and airspeed we have seen that the airplane does not allow you to make those changes smoothly without some stick input. If from trimmed flight you change the altitude by say pulling back on the stick, and then relax the stick pressure after the airplane slows down, the airplane won't immediately resume normal trimmed flight. It has a strong tendency to return to its trimmed angle of attack, but will do it quickly enough that it swings past that angle and oscillates around it a few times until it settles back down. These oscillations occur whenever the airplane is disturbed from its trimmed airspeed or pitch attitude, which is pretty often. The aircraft essentially exchanges altitude and airspeed during these oscillations.[1] These oscillations are slow enough for you to be able to correct them easily. Simply use the stick to counter the tendency of the aircraft to exchange altitude for airspeed or vice-versa. [4] (*Adapt conversation in light of the goal of the section as described above.*)

9.2 "Torque"

Propwash, P-Factor, etc. Brief discussion of when which factor is relevant, and to what extent it is modeled in *IL-2*.

9.3 Engine management

Complex engine management. Find the forum threads with effte, ianboys, myself and others. Use the Deakin articles. Emphasize that these planes use turbochargers and superchargers. This section will belong to the chapter on flight for Forgotten Battles.

9.4 G and its effects

Positive and negative Gs, and their effect on the pilot. For FB, address their effect on the engine (primarily negative Gs).

[1] The oscillations are damped out because the pitch-wise rotation causes the tail to have a different angle of attack than the wings.

9.5 Landing revisited

9.5.1 Practice at altitude

Describe an experiment (and provide a track) that demonstrates the mushiness on the back side of the power curve and how the pilot can experiment with stall speeds given varying degrees of flaps and gear extended. The pilot should note the effect of Climb+Angle of attack=Pitch attitude+Incidence for these conditions. The pilot can also practice setting up a $3\circ$ glide slope, and managing the glide slope with throttle.

9.5.2 Go around or salvage?

Tips on when to admit that a go-around is in order. Especially useful for those in coops and seeking a higher level of realism.

9.5.3 Cross-wind landings

This should be specifically directed towards those nasty cross-wind landings in *IL-2*, and less real-life procedures. I know I stink at them. Tully (possibly someone else as well) has offered to write up some material here.

9.6 Night operations

Night fighting, special considerations for visibility. What to be wary of. What are the issues here?

9.7 Techniques of formation flying

Because the creator of *IL-2* is evil and doesn't want you to learn how to fly, you have the choice of selecting autopilot, which will take over your airplane and fly you to your target with the rest of your flight.[2] Some of us rather enjoy doubling or tripling the time of each mission by flying more or less in formation with our squadmates. The aim of this section is to help you wean yourself from the evils of autopilot and learn to fly

[2] Now that is an example of a lie. All he really had in mind was selling more copies of his simulator.

for yourself. Those who are already such good pilots that they don't need to fly for themselves can skip this section.[3]

Have you ever given much thought as to why planes would fly in formations? It wasn't just to admire the squadron's aircraft, there are tactical advantages to formation flying, as discussed in part in section 8.3.1 on page 75.

[3] If you are offended by this comment, you ought to learn to fly in formation. If you winked at it instead, chances are you can validly use autopilot to save time for your busy schedule, you wimp.

CHAPTER 10

IL-2 features and references

This chapter is organized into sections based on the selection possibilities of the main screen of *IL-2*. It goes beyond a simple description of the basic features to make some suggestions based on user experience. There is also a section on the demo version, which allows you to evaluate the game for free, and one on patches, or game updates, that will help anyone who has just bought the game get up to speed on the current and last version of the sim.

10.1 Pilot

This screen allows you to create, remove and select pilots from a register. When you create a new pilot you can give him or her a nickname. The nickname of the selected pilot will represent you when flying online. For each pilot on the register, the individual control settings will be stored, so when creating a new pilot you will either have to reassign all commands or copy the existing pilot settings from another account that has already been configured. Pilot settings can be done by replacing the `settings.ini` file of the new pilot's folder with the `settings.ini` file of another under the `IL-2 Sturmovik\Users` folder. (*verify*)

10.2 Controls

Your controls are the interface between yourself and the simulator. This includes keyboard commands, the mouse, joystick assignments, rudder pedals and any viewing system (such as TrackIR) and other hardware you've bought or made. Just about everybody will at some time or another want to change their settings to match their flying preferences.

Reaction time can mean the difference between life and death. You don't want to have to delay a reaction because you don't know how to implement it. There are 137 commands listed under Control Keys Reference in the fold-out sheet that comes with IL-2.[1] Many of these are for views or settings in a scale such as for throttle, but there are a lot of commands, and a quick look at the cockpits will remind you why. There's no need to explain the exact function of all of these commands here, because it's already been done, and is hosted at STURMOVIK TECHNIKA [18].

It is worth mentioning that you can choose to do things your way, that is, reassign the keys and joystick buttons to your heart's content. From the main screen, click on `Controls`, then choose the right-hand column of the appropriate entry. A tap of the new key or joystick-button assignment will register the new command assignment. Be very careful, though, assigning a key or joystick button that is already assigned somewhere else will remove the original assignment[2] without a notification, and there is no way to automatically cancel the reassignment. Even if you realize (too late) that a reassignment occurred, to get it back you either have to know what the original assignment was or reset all of the default settings and start all new assignments from scratch.

You can also make one or two assignments to the same control function, or leave it unassigned. Leaving it unassigned can be useful if you really intend never to use it, so that you never accidentally engage that function. Making two assignments for the same function can be useful in that you can backup joystick buttons from the keyboard.

A word to the wise: decide on your system of special control assignments as you learn your own needs and know it well, but be careful not to make more work for yourself than you save. Each pilot that you create can have his own set of customized commands, and indeed each time

[1] Some reduced-price versions do not come with printed material, only the CDROM.

[2] The original assignment is not deleted if the two assignments do not conflict, such as `Look Forward` under snap view assignments and `Center View` under pan view assignments.

you create a new pilot he starts out with the set of default commands. This could come as a shock if you don't discover it before the heat of battle. Creating a new pilot simply means that you will have to make all of your changes again. If you have very many customized settings at all, it is advisable to create a list of them for yourself so that you can re-implement the changes quickly.

You might consider creating a test pilot, perhaps name him Test 'Control' Settings, and practice implementing any changes on him before you go messing with your own settings.

Before we move on, here are some suggestions for useful reassignments to make if you have a joystick with a throttle slider and a few buttons:

`Prop. Pitch 0-9`	Keys 0–9 (throttle settings not needed)
`Weapon 1-4`	Assigning to joystick buttons frees Enter, Backspace, Space keys
`Rudder, Aileron Trim`	Arrow keys without `Ctrl` key
`Look Forward`	Joystick button
`Center View`	Same joystick button as for `Look Forward`
`Elevator Trim Positive`	Joystick button of choice
`Elevator Trim Negative`	Joystick button of choice

10.2.1 HOTAS

HOTAS stands for "hands on throttle and stick." These are the controls in *IL-2* that you can control with a device that has smooth, continuous input, generally referred to as a slider. An example that everybody knows is the throttle slider found on almost all joysticks. If you have a joystick installed, the `Power` HOTAS control probably already says something like `-U Slider axis`. The `Aileron` and `Elevator` controls should likewise be assigned, and `Rudder` as well if you have a twist function on the joystick, or much better, rudder pedals (see section).

In addition to these, you can assign smooth, continuous control to `Flaps`, `Brakes`, `Prop Pitch`, and the various trims. There is significance in the fact that the maker of the sim chose these specific control assignments for smooth control...

10.2.2 Joystick settings

Tully has also offered to write some things here, though he might not touch on all topics.

10.3 View objects

This screen is useful for a few things. One obvious help is to learn what the aircraft, ships, ground vehicles and artillery are in the game, and to familiarize yourself with their external appearance. Learning to distinguish between aircraft types is extremely important, and for surface attack quickly identifying ground vehicles and ships is important. Artillery is less important—they're not highly visible and you'll get to know them by what they throw at you.

Another use of this screen is the text information written for each of the objects. It will help you to learn the strengths, weaknesses, history and specifications of each of the objects, notably the aircraft. You will certainly not want to read all of this info at once. However, do not underestimate the usefulness of this resource. New users won't understand the value at first, but you may well find yourself going there time and again. There is an entire book's worth of carefully researched information there! It is true that you won't find every specification or other piece of information your heart may desire, and there are complaints that some of the basic performance information is missing. It is what it is, you can take issues up with the creators of the game. As it stands, they've provided a wealth of information. You can find similar information for the aircraft at the official website.

10.4 Credits

This section is pretty self-explanatory. If you integrate yourself into the online *IL-2* community, you might start to recognize some of the names mentioned here.

10.5 Hardware setup

10.5.1 Video modes

These settings are directly related to your hardware, specifically the graphics card and monitor. They affect the quality of graphical rendering by telling the hardware how to use its resources. The ability to change these settings in this menu is merely a convenience, because the settings you can change here are the same as several of the options available in `il2setup.exe`. Since you can alter some but not all of the settings here, `il2setup.exe` gives you the full overview, or at least the fullest graphical interface that comes with the game. In order to avoid repeating the information, these settings are not described here. Refer to section 11.1 instead for a detailed description of what all of the options under `il2setup.exe` can do for you.

10.5.2 Video options

These settings are not available in `il2setup.exe`, and instead of telling the hardware what to do with its resources, they tell the game what level of graphical quality should be sent to the hardware for rendering. There are two modes of setting the picture quality: simple and custom. The simple mode gives no control over the individual setup items, but makes sweeping changes with a single selection. The custom mode permits individual settings, and is the more flexible and, generally speaking, more useful mode.

Texture Quality

Visibility Distance

Objects Lighting

Objects Detail

Landscape Lighting Excellent may not be selected if XXX feature is not available from...

Landscape Detail

Clouds Detail Clouds in IL-2 are marvelous, but they do take a lot of resources. If your system suffers in performance, this is one setting you might consider turning back. But oh, those beautiful, highly detailed clouds.

Clicking on `Apply` applies any changes you have made, whereas clicking on `Back` without first clicking on `Apply` cancels any changes.

10.5.3 Sound setup

10.5.4 Input

10.5.5 Network

10.6 Tracks

10.7 Training

10.8 Quick Mission Builder (QMB)

For some people this interface is completely intuitive, for others confusing. It's no reason to brag or be ashamed—people's brains just work differently. The great thing about the Quick Mission Builder, or QMB, is that it is, well, quick, and easy to learn to manipulate. The down side is that it isn't very flexible. This tool is primarily useful for designing and hopping straight into quick encounters or training sessions, without any bother about historical accuracy or a higher level of immersion.

Add comments on how it works.

10.9 Single missions

10.10 Pilot career: campaigns

Use of autopilot.

10.11 Multiplay: flying online

10.11.1 Dogfights

10.11.2 Coops

10.12 Full Mission Builder (FMB)

The Full Mission Builder, or FMB, is the tool to use for creating new missions of all levels of complexity, including simple maps for your own use, online dogfight maps, coop missions, and full-blown campaigns. Unless you fly a single mission, campaign, or other mission prepared in advance by someone else, this is the only method you have for accessing the Berlin, Kuban, Kursk, L'vov, Moscow (summer), Prokhorovka, Stalingrad and online maps, since only the Smolensk, Crimea and Moscow (winter) maps are available from the QMB.

Thanks to the work of a considerate member of the community, there isn't much else to write here in terms of explanations of how to use the FMB. A complete and easy-to-read Mission Builder Guide has been written by Sotka and is hosted at the S T U R M O V I K T E C H N I K A website. It is the general consensus that this is the definitive guide to the FMB. If you start out using only the official notes from the *IL-2 User Manual* [3], you will be able to create missions, but the interface is often counter-intuitive and you will unnecessarily spend a lot of time to figure things out. Questions not covered by Sotka's guide, and these won't be basic, can be asked at the Mission Builder Forum (see section 12.1).

10.13 Demo

There was a lot of anticipation of *IL-2* prior to its release. A part of the evangelical efforts of the 1C:Maddox team was the release of a demonstrative version (demo) with a limited number of features that could be downloaded and installed for free, with the goal of enticing the curious to purchase the game. An updated version of the demo is still available to those unsure of whether they would like the game. The download is about 150 MB, and links to locations where the demo can be downloaded are found on the official website.

10.14 Patches

Since its release in November 2001, a regular series of game updates were released, the final one before *Forgotten Battles* being version 1.2ov (version 1.2 is nearly the same). These so-called patches make a great number of corrections, including flight- and damage-model tweaks, changes in sound, the introduction of new aircraft, etc. A complete list is available on the official site. This list also provides links to locations where the patches are available for download.

How to install the patches

Why I should install the patches.

CHAPTER 11

Technical hints

You've just bought the sim, excitedly install it, and start it up. Oh man, this is just gonna be so . . . what the? It doesn't work? Smeared graphics? Stutter! Three frames per second? What kind of stupid game is this?! Don't worry, you aren't the first. It's happened to a good many of us, and here's the good news: assuming your machine is powerful enough to handle the program, you can get it up and running smoothly.

11.1 Game settings

There are a great many game settings to "worry" about in *IL-2*. In fact they are there to help you out, not to confuse you. In general, the more powerful a tool is, the more you have to invest in learning about it at the beginning. *IL-2* has great flexibility; it can perform on a wide range of systems. These settings are what help you tweak performance for your own system.

As mentioned in section 10.5.1, the settings that will be discussed in this section affect the quality of graphical rendering by telling the hardware how to use its resources. They are different from the in-game settings found under the `Video Options` menu. The principal tool to work with is `il2setup.exe`, or just `il2setup`, and it has a straightforward graphical user interface (GUI) and is located in the `IL-2 Sturmovik` root folder. You can't do everything with that program, however. As a matter of fact, much of what the program does is make changes to text file named `conf.ini`, also located in the root folder. If you open this file in a text editor, you will be able to edit it and make a great deal more changes.

11.1.1 il2setup.exe

The discussion of this tool is divided into its tab menus. The setting `Intro` doesn't belong to any of the menus, and is located at the bottom left of the dialog. If this is checked, the introduction track will play when you start *IL-2* up. It's novel at the beginning, but after a while you will probably want to get rid of it.

Driver

Here you will choose information about which (graphics) provider you want to run the game under, and what video mode to run in. OpenGL and DirectX are the two choices you have for application programming interfaces (API), and there are a certain number of previously determined graphics modes to choose from.

The game is optimized to run under OpenGL, and with most systems you will get higher framerates with it. DirectX, although better supported by Microsoft of course, may or may not make sense, depending on your system. The appearance of the graphics is definitely affected by the choice of API (it is strongly affected by the graphics card), so just experiment with both and see which you prefer. Whichever one you do choose, keep in mind that it will directly affect the best choice of video settings.

You definitely want to run the game in full-screen mode. When running in windowed mode, the system still has to worry about rendering graphics for other elements outside the window, eating up precious resources.

If you don't see the video mode in the list that you would like to have, don't worry, you can set whatever you want in `conf.ini`. See the next section.

Stencil buffer…

Video

Settings

Texture quality

Texture mipmap filter

Texture compression

Detailed land textures

Use alpha

Use index

Polygon stipple

Use dither

Use clamped sprites

Draw land by triangles

Use vertex arrays

Disable API extensions Extensions:

Multitexture

Combine

Secondary color

Vertex array extension

Clip hint

Use palette

Texture anisotropic extension

Texture compress ARB extension

Joystick

There's not much to this one. Here you can enable the use of your joystick, and by clicking on the Properties button open the Windows Gaming Options dialog, where you can calibrate your joystick and rudder pedals (if you have them, and you should).

If you don't have a joystick available yet, get one as soon as you can. It is a question of personal taste whether you want to get the cheapest joystick available, a more reasonably performing joystick, a force feedback stick or the latest HOTAS stick. You can spend anywhere from $30–$300, so suit yourself. If you decide to try and control your aircraft with the keyboard, you very probably don't need this guide.

Sound

Sound is a resources hog. If you're having frame rate troubles, one of the first things you should try as an experiment is turning off sound. You can also disable or reduce the hardware sound acceleration level. If you are using DirectX as a sound engine, you can do this by running `dxdiag` and adjusting under the `Sound` tab.

Network

11.1.2 conf.ini

```
[window]              [game]
width=800             Arcade=0
height=600            HighGore=1
ColourBits=16         HakenAllowed=1
DepthBits=16          mapPadX=0.6689453
StencilBits=0         mapPadY=-0.046875
ChangeScreenRes=1     viewSet=3
FullScreen=1          Intro=0
DrawIfNotFocused=0    NoSubtitles=0
EnableResize=0        NoChatter=0
EnableClose=1         NoHudLog=0
                      NoLensFlare=0
```

11.2 Terminology

frames per second, antialiasing, anisotropic, etc.

11.3 Flight model

Editor's note: taken directly from a forum post by Tully_, *this section needs editing but can be useful anyway.*

There are a bunch of different ways to arrive at more or less the same result, all demanding different amounts of calculations. The more closely you require the sim to match real performance, the more calculation you require and the more powerful the PC you need to do it without suffering an unacceptable performance hit.

Most sims to date have take a short cut by working out a "cheat sheet" of average figures for things climb rate and acceleration at different ranges of speed and altitude. This means that within any given altitude range, performance will not vary.

In order to make the performance in this type of sim realistic, the cheat sheets get very big and have a lot of different performance characteristics recorded. For simple models it provides a huge computer performance advantage, but as the performance gets more realistic, the cheat sheets (in the form of a table) begin to take too much RAM.

Another approach is to use mathematical formula to calculate lift, drag, the effects of control inputs etc. on the fly. This uses much less memory, as only the formulae have to be loaded, but hundreds of time a second for every plane in the mission, the CPU must work out the answer to every formula in use, so you need a much more powerful computer. *IL-2* uses this sort of method. Again, simple models that "gloss over" rarely encountered flight conditions take less computing power, while models that take into account things like ground effect, leading edge slats, undercarriage drag, change in weight and centre of gravity due to fuel and ordnance being expended will require many more calculations and more computing power.

The sim programmers must choose what level of detail will provide the most detail in the flight model without slowing the computer down so much that the game is unplayable. It doesn't matter how fast your video card is if the computer can't tell it where the objects are often enough. You'll get perfectly clear pictures at high frame rates of a warpy slide show if the CPU isn't up to the task.

This compromise between the level of detail of the flight model and the computer's ability to keep up accounts for a lot of the difference between sims. It also explains why 1C:Maddox chose to simplify the flight model for the AI. Making it simpler allows more AI aircraft to be put in the mission without slowing down the computer too much.

A third source of differences comes from the quality of the programmers historical sources. A properly conducted flight test series is more that just the combat envelop graph and list of a dozen or so speed and climb figures. Full test reports can run to hundreds of pages, more than half of which are tables of figures. Developing formulae to model the physics in sufficient detail to achieve results that match the performance tests in every details is extremely demanding on a computer. Full military simulators use all the computing power of a very powerful computer (often multiprocessor) to model *just one* plane. We are (quite unreasonably) hoping that Oleg can perform the same level of detail on machines that run many times slower and for many planes at once. Compromises have to be made and accepted.

If the aim were to simply have a plane that flew like the real thing, with no scenery, gunnery or other planes, you would find that many of the compromises would be less obvious or not necessary at all, but we also demand photo realistic scenery, with both ground and air objects that behave something like realistically and register damage when we shoot at them. Considering what we're asking of our humble desktops, I think we're getting very good results.

Some of the graphical data is calculated by the CPU (position and orientation of objects relative to the aircraft as a result of pilot input changing the aircraft position). User settings like view distance allow the user to take some the load off the CPU. Objects outside the chosen view distance only need to have distance calculated. As long as the distance is greater than maximum view, only that figure is needed. For objects inside the view range, distance, angle, orientation and apparent size all have to be calculated. Obviously, turning down setting like this drastically reduce the number calculation required of the CPU. In this way the developers can build in some user scalable over engineering.

Another aspect of this shows up in tracks. A lot of tracks I've downloaded didn't work right on my old PC (a P3 500). I'm almost certain that this is because it couldn't keep up with the data handling, and consequently some of the recorded control inputs were skipped or applied late. In a mission, the same factor would mean a small (un-noticable to the pilot, particularly at low fps) delay in response to some control inputs while the CPU finishes what it was doing at the time. In really busy online missions you also see slow PC's flying a little unevenly when things get busy. This is because net updates are delayed in the same way on overwhelmed machines.

11.3.1 Known issues

Overbanking, bank angle/dihedral effect and accelerated stall/spin susceptibility, whatever else ... could compile a list.

11.4 System performance

System requirements

CPU

RAM

Graphics card

Hard disk

11.5 Lag

This interesting post was made on the forums by RAF74_Wall-dog*. It hasn't been edited but is also deemed interesting as an example of the kind of advice that can be provided here.*

S! All!

When you start getting into network topics such as lag in a flight simulator, you start getting into some pretty murky waters. How it works is actually entirely up to the code. Il2 however does it the "easy" way - which is to let the computer doing the shooting determine whether or not it registered any hits (as someone else mentioned). There are pluses and minuses to this approach.

The plus is that if you see something you can hit it. If the player computer only sent the server where it fired bulletts and let the server decide based on plane positions what was a hit (which is another way a game could do this) then lag would be a huge issue because you would have to lead your target by enough not only to make up for your target's speed but also to make up for your lag. And while lag may be somewhat stable it DOES change so you would never really know how much you needed to lead.

In a nutshell, you see the player shooting behind you because he is shooting at where you were on his computer when he fired rather than where you are on your computer when he fired. And with a 400 MS lag time plus the other player's lag of say 100 MS, he is firing at where you were on your computer roughly 500 MS earlier. If two players BOTH have 400 MS lag times, then the difference between them is a whopping 800 MS!

Lag makes it harder to evade other people rather than harder to hit them. The reason is that you are seeing the same effect your enemy is seeing - he appears to be 500 MS (in our exaple from above) behind where he is on his computer. So your evasion is occuring 500 MS after whatever your opponent is doing. 500 MS may not sound like much, but consider that if he is close and shooting at you, you will be taking hits before you see him shoot. The only ”good thing” about high lag is that it cuts both ways - you get the same effect against your opponents that they get against you.

Another issue - and I don't know if anyone has done this for IL2/FB (but it was certainly done for RB3D) - is that you can make a ”god gun” by recording the packets your computer sends when it scores a hit, figuring out what part of the packets says ”hit,” and then modifying the packets you send when you fire at other planes to say ”hit” regardless of whether or not you are really hitting anyone. If you think of the packets as saying basically ”I'm at location XY, shooting at plane 123, and missing with 100 % of my bullets” you would simply alter your packets to take out the part that says you are ”missing with 100% of my bullets” and insert something that says ”hitting with 100% of my bullets.”

Now, that's a major over-simplification of how a ”god gun” can be created for a flight simulator (luckily it's not as easy as that makes it sounds!), but it is how it is done. Hopefully Oleg has software within the game's server code that looks for this kind of thing. Red Baron 3D did not have any code on the server that looked for ”god guns” and consequently a number of people had them. It isn't hard to imagine a person programming a hot-key to turn their ”god gun” on and off. When they want to force a hit, they simply hit the hot-key to turn it ”on” and then whatever they shoot at they hit - and they hit with 100% of their bullets (I've been using my parser for over a year now and can see conclusively that the BETTER online pilots only hit with 10% or so of their bulletts - so do the math). Even if Oleg has code to try to catch

”god guns” though, it’s a game of cat and mouse with the hackers trying to figure out how to cheat without the server picking it up.

Other things that are possible by the server letting the planes tell it where they are is the intentional lag-warp that players do. That program has been out for a long time, and I’m sure that it works with FB just as well as it worked with IL2. There was a flag in IL2 that would set a lag limit that made the lag-warp program less effective, but even then people could still use it as long as they didn’t exceed the tolerance the server set. If the server did some of the math to determine where planes were then lag-warp weapons wouldn’t work because the server would know basically within a ”bubble” where a plane COULD be and if someone tried to update their location and the server saw that they were trying to go outside that ”bubble” then the server would know it and could boot them. IL2 did that to a certain degree (hence the ”cheating detected” message) but IL2 seemed to do it based on lag rather than by making some kind of ”bubble” around a plane’s position representing where it is possible for that plane to be when it update’s it’s location. I don’t know how FB does it, if it does it at all (when you tell Oleg not to announce ”cheat” you are discouraging him from building anti-cheat mechanisms into his code - and a lot of people have done that).

The downside of using the server for this stuff is that the algorithms involved would be really complex and would be a big drain on the server. So by letting the player computer control position and ”hits” relatively unchecked, you increase performance but you also make it easier to ”cheat.” Pick your poison. Personally, I’d be willing to tolerate the extra demands placed on servers to know that I had a cheat-free game, and I’m willing to put up with false ”cheat” messages if it will help to the end or preventing cheating.

Cheaters are slugs. It’s a good thing that most of the people with the skill to write cheat programs would rather write ”good” programs like Lowingrin’s or Starshoy’s dynamic campaign programs or like Sturmolog or Tonkin’s Mission Saver (or like the RAF74 IL2/FB Dynamic Campaign System!!) or like any of the other wonderful user-mods out there. But it only takes one programmer who would rather use his skill to destroy a game by cheating rather than to use his skill to enhance a game. Once the program is written it starts getting passed around. I always laugh when I see someone bragging about how they can do this or they can do that when you know that all they are doing is reading instructions on how to use a program someone else wrote. Like it makes them a better person because they can cheat at Red Baron 3D or something. Get a life.

Now I know someone is going to read this and think that I'm telling the world how to cheat. To an extent I am, but you can imagine that the people with the skill to utilize this stuff already know how to do it (it isn't rocket science). I think the community SHOULD know how it's possible to cheat so that they also know what to look for and we can have rational discussions about it rather than arguments that look like religions discussions rather than logical debates.

In my case, if I see someone who is scoring like 20% or 40% hits over a course of time when I know that the BEST online pilots are only around 10% (the parser/reporting section of the RAF74 IL2/FB Dynamic Campaign System tells me this) then I know I should be suspicious. Luckily I've never seen this happen. I've seen players have high hit-rates in individual missions, but I've also seen the same pilots have much lower hit rates in other missions.

And that is the problem! How do you really know what is happening? There IS a lag cheat program out there and there may well be a "god gun" program. But though you can post that it's possible to make these programs you can't prove based on an individual case that someone is using them unless they tell you that they are.

But of course hackers like to tell everyone how clever they are (and it seems that the less skilled they are the more important it is to them to make people think they are clever). So over time we know who they are. How many times for example have you seen individual pilots telling everyone how great the trim-cheat was? Do you think the same pilots would hesitate before using a lag cheat or a "god gun?" No. And they would brag to people within servers that they were doing it. Nobody knows how clever they are unless they get caught. Such is the beauty of the human ego. I say that if someone tells the community that they are a cheat than we should take them at their word and label them as such. All of the cheaters eventually tell people that they are cheaters - and when they do we should take them at their word. I'm not going to post any names here, but all of us who have been around for a while know who they are. Knowing what to look for only makes it easier to see when someone is doing it.

Anyway I digress. The point is that lag does matter but not in the ways that most pilots think that it does. As long as it's stable it's not that big an issue, but it does make it easier to hit targets and harder to evade targets thanks to the way plane positions and hits are done. And of course it makes it easier to cheat.

11.6 Useful external hardware

Joystick, throttles, rudder pedals, TrackIR

11.7 Further help

This chapter may have helped to clear some things up for you, but chances are it hasn't you still have some great, unsolvable problems to solve. Competent help is not far off. After you have tried to understand the problem and gathered information about it, head on over to the Technical Support forum at the Ubi forums, which is described in the first section of the next chapter (section 12.1).

CHAPTER 12

The *IL-2* community

12.1 The official forums

Some (serious) comments about what can be expected to be found at the UbiSoft forums. These forums are also linked from the official site and are:

- General Discussion
- Technical Support Forum
- Squadron Forum
- Oleg's Ready Room
- Mission Builder Forum
- Paint Schemes Forum
- Chat Room

12.2 Online resources

It is possible that short reviews of relevant websites and online resources are beneficial here. At the moment there is an appallingly short list of links at Eastern Skies, which will at least lead to sites with more complete list of links.

12.3 How much is too much?

The sim bug has a nasty bite. You might want to get that looked at. Others who have gone before you have found their answers to the question. "You know you play too much *IL-2* when. . . "

- you feel uneasy when travelling under 160 kph. (YaksKill 12/28/01)
- you try to explain to people how the nose cannon in a Bf-109 can't hold a candle to the quad 20 mm cannons in a FW-190, and can't seem to get through to them. . . (Harry14843 12/28/01)
- you see a girl walking by and you hate RL for not having zoom (weasel75 2/15/03)
- someone changes lanes to get behind you and you instinctively try to get behind HIM. (mllaneza 2/15/03)
- your car pulls to the left due to bad alignment, and you look for the rudder trim knob to correct for it. (I really did this!) (Metlushko 2/16/03)
- you pull into the driveway, park your car, leap out and run 50 yards and throw yourself on the ground cos there's *always* a vulcher somewhere. (LvT)
- you are lost in thoughts (about *IL-2*, sure) and yr wife shouts suddenly "you are flying again, aren't you?" (Jurinko)
- . . . you get nervous when you hear the song "Yakkity Yak." (STRIDER_EB 04/03/03)
- your passenger airliner makes some hair-raising corrections at landing and you love every minute of it. (Spiffae 04/03/03)

12.4 Squadrons

CHAPTER 12

Acknowledgements

There are a fair number of people who have stepped forward to offer their help with this project. There is a organizational list of potential and actual contributors exists on the Eastern Skies. Sadly, the hurried preparation of this document for a public evaluation has so far prevented it from being re-assembled. A smaller group (all from the Ubi forums) than have offered help have been able to bring significant contributions. Most significantly, mikeyg007 wrote section 8.1 on ground attack and did a lot of encouraging. Tully_, effte and Loco-S all three willingly provided their considerable knowledge of aviation and *IL-2* in an effort to evaluate, correct and add to the project. All three of these have offered good advice, encouraging correspondence and material to add to the book and website. Loco-S in particular has contributed large amounts of downloadables, some of which is still waiting on confirmation of copyright non-infringement. Recently he has also sent a lot of additions to the chapter "Ground school." These are still being reviewed.

Ham, who made and runs the incomparable STURMOVIK TECHNIKA, gladly consented to let me steal some of the web layout and look for my version of the Eastern Skies website. Simon Griffee (sgriffee) put a lot of effort into giving the Eastern Skies site a professional facelift. The code is ready and has long been held up by the technical difficulties involved in finding access for him to a server that can host the site.

There are more, to be sure. The credits will be zealously updated as soon as possible.

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