A User's Guide to

IL-2 Sturmovik

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

version 0.2
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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, and to all who suffered or died in that tragic struggle. We who fly are fascinated with machines and combat, but we wish to honor with heart and mind those poor and brave souls.

When morning lights the eastern skies,
O Lord, Thy mercy show;
On Thee alone my hope relies,
Let me Thy kindness know.

For Thy Name's sake, O gracious Lord,
Revive my soul and bless,
And in Thy faithfulness and love
Redeem me from distress.

Extract from *The Psalter,* 1912

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Acknowledgements

It is appropriate that Mark “Shoot” Kratzer, whose work STK/EAW gave me the idea for the *IL-2* Guide, be the first to receive thanks. Without his initiative, I likely never would have decided to take on this project.

Many thanks go to Oleg Maddox and the 1C:Maddox development team, for their creative labor, patient dedication to both product and community, and surprising depth of attention to detail.

Since the idea for this project started in September 2002, there have been a fair number of people who have stepped forward to offer their help with this project. In particular is mikeyg007, who wrote chapter 7 on ground attack and encouraged me greatly, and Dart, who humbly contributed section 8.4 about online etiquette without complaining about my slowness. Tully_, effte and Loco-S all three willingly provided their considerable knowledge of aviation and *IL-2* in an effort to evaluate, make corrections and add to the project. All three of these have offered good advice, encouraging correspondence and also material to add to the book and website. Loco-S in particular has contributed large amounts of download material.

Ham, who made and ran the late great Sturmovik Technika, always gladly helped me and was a voice of experience, is much appreciated. Grateful thanks go to Simon Griffee (sgriffee), who freely contributed to a new CSS-based design of Eastern Skies, which I adapted to achieve its facelift.

Hristos, MajDeath, FW190fan and JG14_Josf made valuable contributions to the interview that provided extensive information for the FW-190. igor_firebird contributed the information in 2.2 for the MC.202. JG14_Josf, JG14_Hertt and Old_Canuck are kindly thanked for their contributions to the

community tracks page. (Others are encouraged to contribute!) JG14_Josf is especially appreciated for his collaboration in the preparation of material for the as-yet incomplete chapter on combat maneuvers and tactics.

There are others, to be sure. The credits will continue to be updated as contributions are made. If I've overlooked you and you'd like to have your name included, please contact me through Eastern Skies.

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 Soft *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

This guide has been written out of love for the game and in the hope of helping others, thereby bringing the *IL-2* community closer together. It still is a work in progress, and putting it together is done during free time. There are bound to be inconsistencies, errors and omissions. Please submit suspected mistakes (besides areas where the work is clearly not finished) by dropping an email at the official site. You might even consider sharing some of your knowledge by contributing.

This is the second public release of the guide, and labeled version 0.2. Here is a list of changes made since the first release (version 0.1).

- Update of the chapter "Introduction"
- Removed empty chapter "Air war on the Eastern Front." If you or someone you know would like to write on this historical and relevant topic, please contact me.
- Substantial progress on the chapter "Machines of war," including implementation of information from the FW-190 interview
- In the chapter "Flight": changes to section *Stalls*, section *Changing altitude and airspeed*, section *Take-off* changed, removed the small section on yaw (the material was simply redistributed), section *Level flight* added renovation of the section *Turns*, section *Landing* finished, section *Airfield operations* added and section *Spins* finished
- In the chapter "Combat fundamentals": section *Gunnery* expanded, small addition to section *Situational awareness*, section *Engine man-*

agement partially updated, finished section *Combat procedures* (was previously *How to get started*)

- Chapter "Combat maneuvers" dumped; concept of chapter "Fighter combat maneuvers and tactics" planned as replacement
- Finished editing the chapter Ground pounding (was "Ground pounding and combat fundamentals"); some material moved out
- Removed chapter "Advanced topics," this material may be reorganized into an appendix later
- Added new chapter "Flying online," featuring Dart's section *Online etiquette*; chapter is partially incomplete
- In chapter "IL-2 features and references": worked on sections *QMB*, *FMB*, *Single missions* and *Campaigns*
- In chapter "Technical hints": section *Screenshots* added; otherwise this potentially useful chapter unchanged
- Typesetting corrections, numerous small corrections and updates of outdated resources
- Some other stuff probably went forgotten

The document was prepared with the LaTeX 2_εsystem using PDFTeX, and it was used to embed hyperlinks directly in the PDF format. You should be able to click links to navigate about the document, and if your PDF program is configured to enable it, many links will open the linked website in your browser. In addition to a linked table of contents, in Adobe®Acrobat Reader®(and possibly other PDF readers), the bookmark feature allows you to always have a window frame open for easy navigation.

For some still unknown reason, there is an error with the automatic figure references. Hopefully the reader will be able to work out which figure is being referred to. The references are clickable.

The current page format is A4, the European standard for "normal" printing, although the page layout is conservative and can easily be printed in Letter format ($8\frac{1}{2}'' \times 11''$). 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-sided and single-sided layouts.

If you would like to submit a track for use with this guide (see examples at the Eastern Skies training page), please do so using the address found at the Eastern Skies website.

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!

A chapter was planned to provide a glimpse into the horrible, historic 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 comprehension is awing, and is to be appreciated. It is important for the reader to create a sense of immersion in the sim, which the content of this user's guide cannot accomplish. Such an account ought to focus on the air war and the hardy men and women who carried it out and lived to tell about it. Unfortunately, this important chapter is unwritten and significantly unresearched by the guide's authors. Authors for this chapter are *quite particularly* welcome. A historical background has been written by the developers of *IL-2*, and is highly recommended for a context and sense of the campaigns involved.

The chapter "Machines of war" will supplement the generous helping of information found in the in-game 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 and filled out with some factual information.

"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. 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 combat maneuvers are discussed in a later chapter.

"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. Important parts of this chapter are still incomplete.

The majority of aircraft in *IL-2* are fighter aircraft. These aircraft have the purpose of shooting other aircraft down, and are to be differentiated from ground-attack aircraft. "Fighter combat maneuvers and tactics" is a chapter in the planning stages that introduces the student combat pilot to the relevant concepts of air combat in a fundamental approach. Included are combat turns, types of pursuit, basic fighter maneuvers, angle and energy tactics, and section tactics.

"Ground pounding" gets into the basics of the nitty-gritty business of slamming hardware into the mud and ice while presenting yourself as a target to bloodthirsty defensive batteries.

"Flying online" is meant to help you get started in your online adventures, and offers a few reminders that will help you be prepared for what may be expected in terms of behavior. This recently added chapter is still incomplete.

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. Parts of this chapter are still incomplete.

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. This chapter needs to be trimmed and completed.

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.

A section is planned for an appendix entitled "Advanced topics," which is to pick up on some of the loose ends where "Flight" left off, going into further practical detail about flight.

CHAPTER 2

Machines of war

But owing to the unlucky discovery by an immature civilisation of the internal combustion engine and the art of flying, a new weapon of national rivalry had leapt upon the scene capable of altering much more rapidly the relative war-power of States.

— *Winston Churchill on the rearming of Germany*

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 Ubi Soft *IL-2* site, from which some of this material has been taken, as well as in the in-game Object Viewer, which is selectable from the main menu. Furthermore, there is a less advertised but still quite helpful resource provided by the official site on their media page: in their site kit are the three documents `USSR_planes`, `German_planes` and `ALL_vehicules`, which contain technical and background information about aircraft and ground vehicles used in the game. These and a few other documents have been extracted from the rest of the site kit and are hosted on the technical page of Eastern Skies.

The goal of this chapter, however, is not to repeat information that is already available to the user in the game and its documentation, since the 1C:Maddox team has already provided it. Rather, the intent is to provide a *short overview* of how and when the aircraft were historically used, accompanied by practical information about how the aircraft perform in the sim based on user experience and in-game user research on the planes. This might include a general overview of the basic role 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. A notable but regrettably isolated example of how such information can be gathered from the community can be seen in this thread in the General Discussion at the Ubi forums.

In the preparation of this material, numbers and historical use of the aircraft was gathered in part from reference books and Internet sites. Material was in particular borrowed from the Rand McNally Encyclopedia of Aircraft [1]. Books, being published and subject to an editing process, are more accountable and have been preferred. Internet sites, however, can be rather well researched and authentic. Discrepancies are found even among books of course, and as the authors are not themselves historians, no particular claim is made as to the authenticity of the information made available here.

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 number of the aircraft types are unavailable in the original, out-of-the-box release, but all are available with patch release version 1.2. See section 9.14 for information about patches.

2.1 Aircraft of the *Voyenno-Vozdushnyye Sily*

Before the beginning of the war, the *Voyenno-Vozdushnyye Sily* (*VVS*), meaning military air forces, was one of the largest air forces in the world. Its aircraft, however, were quite obsolete and proved themselves incapable of competing with the superior organization and aircraft of the *Luftwaffe* of the invading German forces. Yet what the Russians lacked in technology, they made up for in spirit and in numbers. Early on, important aircraft manufacturing plants were relocated west of the Urals, out of range of the German strike capability, who had no usable strategic bombers. This industry was to prove to be critical later on, as the Soviets showed tremendous innovation in their craft, and by mid war production numbers soared. The Soviet forces were supplemented by the American lend-lease program, enabling them to use more modern fighters than they were able to use themselves. By 1943, the *VVS* was able to field fighters that could easily compete with the once-superior German forces, and German air superiority was no longer a matter of course.

Soviet aircraft designation uses either initials of the names of the design or factory engineers or an initial system: “I” stands for *istrebitel* (fighter) and “U” for *uchebny* (trainer). Aircraft marked with a ★ in the margin are flyable by the player, others are AI controlled only.

2.1.1 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 competing in horizontal maneuvers with propeller-driven fighters. The controls are simple, landings are a challenge, and a short campaign was provided with the patch that introduced it. ★

I-153 The “Tchayka” (seagull) is a fabric-covered, single-seat, open-cockpit biplane fighter. Designed in 1937 as a further development of the 1933 I-15 by Polikarpov, it is several years younger than the I-16 and was the last mass-produced Soviet biplane. Its marvelous design, including the retractable gear and a new 1000 HP M-62 engine, and high quality of mass construction made it a very fast pre-war fighter and extremely nimble. However, its speed was far too low for the rapid advances of the period, and it was only used in the first few years of the war, serving until 1943. Its armament of of four machine guns (or 2 20 mm cannons in the P model) was also strong for the period in which it served.

I-16 The Polikarpov I-16 ”Ishak,” Russian for Little Donkey, was a mainstay of the *VVS* at the beginning of the war, but, just as even the modern aircraft of the *VVS*, was outclassed by the *Luftwaffe* fighters when Operation Barbarossa began in 1941. It is quite maneuverable and although it can’t keep up the German fighters’ high speed, it can easily out-turn them and is extremely dangerous when it catches them up close. The fighter served until 1942, when it was replaced by the increasing number of 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, although this had to be cranked 33 times 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.

In the game, it is necessary to create key assignments for the `Rise Gear manually` (rise as in raise) and `Lower Gear manually` controls and to press these many times in succession in order to simulate manually lowering and raising the gear.

LaGG-3 This initial development by the team of engineers led by Lavochkin and his assistants Gorbunov and Gudkov had an all-wood construction. It was produced in large numbers and helped the Russians gain much experience in mass production [1]. Although not a phenomenally outstanding fighter, it was produced in large numbers and helped modernize the *VVS* in the post-invasion period of 1941 and 1942. In this time period it is a capable aircraft with good maneuverability. Although it quickly loses speed during hard turns, is slower than the German fighters and not a quick climber, it nevertheless has a strong armament that is better to be well respected by *Luftwaffe* pilots. It was replaced by the next Lavochkin design, the La-5, in 1943.

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, and is equipped to 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.

MiG-3 Together with the LaGG-3 and Yak-1, the MiG-3 was one of the few modern fighters of the *VVS* in the first year of the Eastern Front, the MiG-3 being made available toward the end of 1941. It is a high-altitude interceptor and the fastest of such in the first years for the Soviets. Unfortunately, it is weakly armored and often catches fire when hit. At low altitudes it turns slowly and has poor maneuverability, but at high altitudes fast the only interceptor in its time capable of dealing with the superior German fighters. Because of its relatively poor low-altitude performance, some 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 light machine guns and one 12.7 mm heavy machine gun, the armament is not overwhelmingly 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 to arrive on the front lines in late 1942. The aircraft was designed around its armament, namely the 37 mm T9 cannon that fires through the propeller hub. The variants also have .50-caliber (12.7 mm) heavy machine guns, and .30-caliber (7.92 mm) machine guns. With these and the 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 always save ammo.

The placement of such a whopping cannon in a small fighter was made possible by placing the engine behind the pilot, a revolutionary design at the time, and one that helped establish its fledgling maker, Bell. This shift in weight distribution and the leftover space up front made the implementation of tricycle gear possible, and the P-39s are the only planes in *IL-2* with tricycle gear. In addition, the weight required to secure the engine also makes the Cobra somewhat underpowered. The rearward center of gravity due to engine placement helps the P-39 in regards to maneuverability, but also gives it a nasty spin characteristic, which requires some patience (and altitude) in the spin recovery procedure (see section 4.9). She can turn well, but always be fairly gentle on the controls. As a 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 Airacobra 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, and early trial models were passed over by the British and on to Russia. Soviet pilots took advantage of its superb low-altitude performance and used it to great advantage, as reported in [2]. It is certainly well documented that of the slightly more than 9,500 Cobras of all types built, just over half were sent to the USSR.

You can find a cockpit reference for the P-39 at Eastern Skies. All three models (N-1, Q-1, Q-10) have a nearly identical cockpit layout. As an American-built aircraft, the gauges use non-metric units such as airspeed in miles per hour (mph) and altitude in feet.

PZL P.11c This delightful plane was already hopelessly outmoded at the onset of the 1939 *Blitzkrieg* into Poland. It climbs well at low altitudes due to its light weight, and although it is quite maneuverable and therefore hard to hit, it is woefully underpowered and slow and has a weak armament. Nevertheless it is a mistake to disregard or dismiss it.

Yak Aleksandr S. Yakovlev's first fighter design, the I-26, began production in 1940. It was armed with a ShVAK 20 mm cannon and two 7.9 mm cannon and had some technical difficulties, which were worked on during production, which slowly increased. By the end of the year, Stalin ordered the aircraft to be renamed the Yak-1. The Yak-1 *Krasavyets* (beauty) made its first public appearance at an air display on November 7, 1940.

Until the introduction of the La-5 into service in 1943, the Yak-series fighters, affectionately named "The Little Ones" on the front, were the most important Soviet fighter. It remained a leading fighter throughout the war, and with over 30,000 units produced was present everywhere. When the war began, the LaGG-3 and Yak-1 were essentially the only modern fighters available to the Red air forces. About 400 units were available when the

German attack came in June 1941, and by the end of the year over 1,000 Yak-1s had been manufactured. In September 1941 the Yakovlev factory was relocated from Moscow to the Urals, but production was again soon underway, and after three months, production numbers were larger than before.

Each new variant of the Yak series represented an improvement. In the summer of 1942 several valuable, major changes were made, including engine and armament upgrades and a three-piece, all-round vision canopy. The new aircraft was unofficially called the Yak-1B by field units. Production of Yak-1 types was continued into 1944, with over 8,600 units produced.

The Yak-1 and Yak-3 types represent the "lightweight" branch of the Yakovlev fighter development. A two-seat trainer was offered by Yakovlev from the beginning, which was essentially a modified version of the (pre-Yak-1) I-26. The design of this trainer evolved parallel to the Yak-1 series under the designation of the Yak-7 series. In 1941, the great need for fighters motivated development of the trainer into a fighter, in which the rear cockpit was replaced with a fuel tank, along with several other necessary modifications. A few of these (about 60) were available by the end of 1941, and improvements continued into 1942, leading to production of the Yak-7B in 1942, which received a radio, an improved engine (the M-105P) and an upgrade in armament with the ShVAK 20 mm cannon in addition to the two 7.62 mm light machine guns. This somewhat heavier Yak fighter type was a bit slower and less maneuverable (by Yak standards at least) than its contemporary Yak-1 variants. Over 6,300 of the several Yak-7 variants were produced, ending in early 1943.

In 1942, development of the Yak-1 further evolved into the Yak-1M, re-designated the Yak-3. (An earlier developed type also going by the name Yak-3 had been abandoned in late 1941.) The more powerful Klimov M-105PF engine was implemented, the wingspan was shortened, it was given a new canopy with even better visibility, and the radiator was moved from under the nose into the wing roots. A powerful armament for such a light fighter was adopted: two 12.7 mm (.50-caliber) heavy machine guns and one 20 mm ShVAK cannon. As with all Yak models, the supercharging system used meant that it performed best at lower altitudes, and the Yak-3 did best under 3,500 m, where it had true superiority to its German opponents and quickly proved itself. The earliest of this type were made available in 1943, but was first available in large quantities in the summer of 1944. The Yak-3 turned out to be one of the lightest, nimblest fighters of the war, and it was well respected. A *Luftwaffe* directive from the front advised: "Combat under 5000 m with Yakovlev fighters without a radiator under the nose are to be avoided."

It must be again be emphasized that the Yak-series fighters had superiority at low altitudes. One source [3] reinforces this with a report on typical Yak-3 tactics: "As well as performing the role of interceptor, it was extensively employed in close support of the ground forces, and for the escort of Pe-2 and Il-2 assault aircraft, on formation of Yak-3s preceding the bombers and attacking German fighter airfields while another provided closer escort."

The high-altitude superiority of German fighters prompted their extremely common tactic of a surprise bounce from above, the well-known "boom and zoom" attack. To counter this, Russian pilots adopted a countermeasure of regularly flying at full throttle (not emergency power). This burned a lot of fuel, negatively affecting its effective range and endurance. This limitation was addressed in the progression of the design of the Yak-7, backed by the experience of constructing the Yak-1 and Yak-3, producing the first all-metal Yakovlev fighter, the Yak-7D *Dal'ny* (long range), whose metal wings allowed for added fuel stores though at the cost of added weight. This was finally put into production as the Yak-9, early models reaching the front lines as early as late 1942 and participating in the Battle of Stalingrad. Production was in full swing by early 1943, and by mid-1944 the Yak-9 variants had become by far the most numerous, with more Yak-9 fighters in service than all other Soviet fighter types combined.

Several variations of the Yak-9 are modeled in *IL-2*, including the long-range escort Yak-9D and those equipped with large-caliber cannons: the air-to-air Yak-9T *Tyazhelowooruzheny* (heavily armed) with its NS-37 37 mm in the spring of 1943 and the Yak-9K *Krupnokaliberniy* (large caliber version) with an increased-caliber NS-45 45 mm visibly protruding from the propeller hub, which did not reach production. Also available is the Yak-9U *Uluchshenny* (improved), truly an outstanding performer and comparable in performance and handling to the famous P-51D Mustang. The Yak-9U first became available in December 1943.

The information presented on the Yak fighters was obtained from sources [3, 4, 5].

2.1.2 Ground-attack aircraft

Il-2 The Ilyushin 2 *Sturmovik* is an absolute joy to fly. The Russian leaders recognized the high value of supporting their front lines with highly specialized ground-attack aircraft, and this design of Sergei Vladimorovich Ilyushin was more than highly successful in this role, especially useful against tanks. That this need of the ground forces for air support was met by the Il-2 is aptly described by Stalin's famous quotation, "They were as vital to the Russian army as oxygen and bread." The design was made in 1938 and they first saw service in the summer of 1941, just in time for the German invasion.

Armored like the tanks it attacks, the entire front part of the aircraft is constructed of a single armored shell. This makes the Sturmovik somewhat lumbering, but it is armed to the teeth and even able to get air kills, especially unwary figthers and slow bombers. It is very difficult to stall, and essentially will not spin. Poor rear visibility is compensated in later models with a rear gunner.

There are a great variety of Il-2 types available 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. The modifications were made to improve both offensive and defensive armament. It was recognized fairly early on that a rear gunner was needed, and some models were modded in the field to achieve this. The modification of course introuced aerodynamic problems, and the M3 model, of which the most units were produced, introduced the incorporation of a rear gunner as part of the design. There were 36,183 Il-2s built, more than any other type of aircraft in history [3].

Note that the Ilyushin 2 aircraft is designated as Il-2, while the game *IL-2 Sturmovik*, which is indeed named after the Il-2 aircraft, uses a capital "L." The aircraft is named after S. V. Ilyushin, hence the lower-case "l." The game was named *IL-2 Sturmovik* by its makers, so this abbreviation is retained here, while Il-2 is used as in literature to refer to the aircraft itself.

Aircraft to be added: Pe-2, Pe-3, Pe-8, Tu-2S

2.1.3 Transport and reconnaissance

Aircraft to be added: G-11, Li-2, MBR-2 AM-34, R-10 and U-2VS

2.2 Aircraft of the *Luftwaffe*

The German *Luftwaffe*, literally meaning air weapon or air force, was the most powerful, most advanced air force of the world as Hitler-led Germany began its domination of the European continent. The critical role it played in the astounding early-war gains served it well, and it was an experienced air force that confronted the Soviets in the 1941 Operation Barbarossa. In the first year or so of the war, it overwhelmed the numerous but obsolete aircraft of the *VVS*, but such superiority was not to last indefinitely. As the

war dragged on and the German forces had to suffer through the harsh Russian winters, resources became increasingly thin, and the quality of aircraft manufacture suffered. Despite this, tremendous gains in aviation knowledge and practice were made by the Germans during the course of the war, and the late-war plans for aircraft that were never realized are truly astounding.

German aircraft designation uses the initials of aviation company that produces the aircraft: Bf stands for Bayerische Flugzeugwerke, Fi for Fiesler, FW for Focke Wulf, He for Heinkel, Hs for Henschel, Ju for Junkers and Me for Messerschmitt (this name replaced the Bayerische Flugzeugwerke). Aircraft marked with a are flyable by the player, others are AI controlled only.

2.2.1 Fighters

Bf-109 The Messerschmitt 109, a single-seat, all-metal low-wing monoplane fighter was a mainstay of the *Luftwaffe* throughout the war. This revolutionary, advanced design began in 1934 as one of the early monoplane designs.

This essential German fighter deserves a thorough review, which is planned for a future edition. Bf-109 types available in *IL-2* are as follows: in the E-series (Emil) are the E-4, E-4/B (*Jagdbomber* or "jabo," meaning fighter-bomber), E-7/B and E-7/Z; in the F-series (Friedrich) are the F-2 and F-4; in the G-series (Gustav) are the G-2, G-6 G-6 late and G-6/AS; and in the K-series (Kurfurst) is the K-4.

The 109 may go by the name Me-109 and Bf-109. This is because the Bayerische Flugzeugwerke AG was renamed Messerschmitt AG in July 1938. Designs previous to this, including the 109, are officially labeled using the Bf prefix. However, many non-official sources use the Me prefix, and is perfectly acceptable.

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 1941 over the English Channel, the first-class qualities of this high-altitude fighter were swiftly recognized, and it was considered to be the most superior fighter of that time. In *IL-2*, the earliest model (the A-4) appears in 1942. There are three types available for you to fly: the FW-190 A-4, A-5 and A-8. The FW-190 D-9 is present as AI only.

An interview of experienced virtual FW-190 pilots was conducted at the Ubi General Discussion forum, including Hristos, MajDeath and FW190fan and JG14_Josf. The following information comes from that interview.

The Focke Wulf is a very direct aircraft, able to rush in, deliver a death blow and quickly leave with no questions asked. All models have a very fast horizontal speed compared to their contemporaries, and the armament on all models is strong and among the most powerful of any aircraft in the skies. It is an excellent diver and has a rugged design, able to bring its pilot home after much damage. These qualities make it ideal for attacking bombers and scattering enemy formations. The A-8 is particularly suited to killing bombers, especially if equipped with MK 108 cannons.

The key to the devastating armament that all 190's have are its 20 mm cannons. In particular, the high-velocity, 20 mm MG 151/20 cannons are accurate, powerful and have low recoil, possibly making them the best all-around gun in *IL-2*. The later models add more of these cannons. Due to this impressive weaponry, the plane lives from snapshots and slashing attacks. A good convergence range for the 190 is 200 m for all guns (the convergence of the nose and inner-wing cannons are tied together; the outer-wing cannons are controlled with the cannon convergence setting), because it allows to hit targets in a large range of distances. However, each pilot must experiment to find what best suits personal taste. The large variety of possible armament and loadout changes possible through the U and R variants of each model adds to the 190's versatility, making it an excellent high-speed, light ground-attack aircraft.

Use the rudder to avoid yawing while shooting. The 190's armament provides a fair amount of scattered but powerful fire outside the convergence range, but if your gunnery skills are good enough to be able to aim at precise sections of the target, consider the following. Against fighters, just aim for the cockpit and engine. With medium bombers, go for the wing roots or tail section. For large bombers, go for the wings in general.

The poor forward visibility from the FW-190 cockpit hinders gunnery to some extent, but by no means does this make it ineffective. Given the element of surprise, it may be helpful to dive behind opponents with and attack from the low six-o'clock position. Visibility in all other directions is excellent, especially below and to the sides. This makes it easier to spot enemies below. One successful tactic is to fly 1000 m above the enemy's anticipated position, then fly slightly to the side of their flight path to get a clear view and make yourself less visible. The element of surprise is very important; for this reason the 190 is at an advantage in servers with icons, external views and padlock turned off.

The 190's are very modern, well-equipped aircraft with an excellent cockpit design. Many gauges are installed, and the principle gauges are placed on top for ease of visibility. An artificial horizon is installed for blind flight.

There are no special issues concerning take-off and landing, except for the poor forward visibility. This can be compensated by skilled pilots during landing by flying a curved approach or by crabbing (cross-control using rudder and aileron), and somewhat during take-off by raising the tail early with the elevator or centering the plane by looking at the runway edges. In the take-off flap configuration, rotation can be made at speeds above 160 kph, or 170 kph with payload. Touchdown speed is 150–160 kph in all models, with an approach speed of 180–200 kph.

The weak point of the FW-190 is its wings: the vast majority of catastrophic damage comes from the loss of a wing, and even small amounts of damage can reduce performance. In addition, with its high roll rate and absence of aileron trim, damaged wings complicate the controls significantly. Next is engine damage, which typically occurs in head-ons, something to avoid in the Butcherbird despite its strong armament. Another small weak spot is the canopy; the pilot may be killed by aircraft with a high rate of decent-caliber fire, such as the .50-caliber heavy machine gun. The fuselage is very sturdy and almost never causes major failure.

Tactics in the FW-190 are fairly specific. Its superior speed should be used to advantage to avoid having to engage enemy fighters close in. It is purely a hit-and-run fighter, not really even boom-and-zoom. Like the 109, they enjoy increased relative performance at altitudes above 3000 m, and high altitudes are to be strongly preferred. Maintaining an energy advantage in this aircraft cannot be overemphasized. If you are slow with an enemy nearby, you have already made a big mistake. The skilled Butcherbird pilot must learn to maintain energy through maneuvers, avoiding energy bleed. Look for opportunities to build speed and altitude.

The FW-190 in *IL-2* does not lend itself very well to energy tactics, counter to the historical combat records. This is a question of relative aircraft performance, and in *IL-2* the 190 burns energy too quickly to dominate using energy tactics. This is not to say that energy tactics cannot be used, but there is no significant performance capability in the areas where energy fighting is adaptable in regards to the FW-190.

When caught, a practiced pilot can use combat flaps[1] to make tight and slow turns inside the opponent. A better alternative is to enter a barrel roll fight, performing wide, low barrel rolls that conserve energy and make you a difficult target, and using the 190's nearly untouchable roll rate to cause the enemy to overshoot, then extend away while they reverse. The most dangerous enemy in these situations are those with a large cannon.

If you've gotten yourself into a pinch but have altitude, then dive at full power to escape. All models of the FW-190 series can out-dive most opponents. The break apart speed is roughly 810 kph IAS.

Here are a few simple rules. Always stay fast. When the enemy is near, you should be doing at least 400 kph with you, preferably 500 kph or more—this should be your first priority when starting engagements. Go for deflection shots. The 190 is well equipped for it, and you can get planform shots where hits are most lethal. This also minimizes the enemy's chance to hit you when you pass him. Use gentle maneuvers, concentrate on speed and nose low maneuvering when enemy aircraft are near, and grab altitude when they are not. Dive when in trouble, avoid nose up maneuvering when enemy aircraft are near.

He-162 The call for a *Volksjäger* (people's fighter) is an astonishing late-war accomplishment that went from drawing board to flight in only three months. This very hurried project (code-named "Salamander") managed to produce the Heinkel 162, "unique in the history of aviation as the only aircraft in which development, pre-production prototypes and main production lines were started almost simultaneously and proceeded in parallel." Curious in the design is the location of the jet engine, mounted on top of the fuselage directly above and behind the cockpit; this motivated the installation of a simple ejection seat, reflecting that the pilots were more highly

[1]This applies only to the *IL-2* flight models.

valued than the aircraft itself. [6]

The aircraft itself was very effective as a fighter interceptor, equalling the Me-262. In some ways it was superior: "The BMW engine proved to be far less sensitive to throttle movments than those of the Me 262, though still prone to flameouts. This allowed the He 162 to be flown up to the limits of the pilot's confidence in the aircraft, unlike the Me 262 whose engines restricted much in the way of maneuvers [6]." It was very fast and well armed. However, it had a problem of having a very short flight time of 30 minutes, and many operational losses were due to running out of fuel.

Despite its rapid development and excellent qualities, it was another case of too little to late for the *Luftwaffe*. The production program was planned to put out 4,000 aircraft per month, but only a few hundred were in fact produced because of the success of the Allied bombing campaign. Although a very few He-162s did see action over Germany in April 1944, the fighter essentially had no impact on the war.

I.A.R. 80 The Romanians realized in the late thirties that their Polish fighters were obsolete. The *Industria Aeronautica Româna* factory offered an elegant design that incorporated many parts of the older Polish P-24 in use. The first batch of the resulting IAR 80 left the production facility in February 1941, having finally received the necessary materials for production after joining the axis in November 1940. [6] The IAR 80 is the only Romanian fighter aircraft of original production that served in the war, and it served effectively with distinction. About 120 were made, and it remained in service until 1944. It is not particularly well armored or very fast in comparison to its opponents, but quite maneuverable and well armed with 2 7.9 mm machine guns and 2 20 mm cannon.

The IAR 80, IAR 81 and MC-202 are the only Axis aircraft in *IL-2* that do not actually belong to the German *Luftwaffe*.

MC-202 The MC-202 "Folgore" (thunderbolt) was a development of the MC-200 "Saetta", of which it retained most of the fuselage and wing structure. The original radial engine of the MC-200 was replaced with the more powerful V12 Alfa Romeo RA 1000, actually a licensed version of the German DB 601. The open cockpit was replaced with a closed cockpit, but the weak armament of its predecessor (only 2 12.7 mm machine guns) remained unchanged and represented the main flaw of this aircraft. Like most Italian fighters of WW2, the Folgore had excellent maneuverability; it was superior to the Hurricanes and P-40s but easily outgunned by the Spitfires. Quite oddly, the MC-202 was only marginally used in the Eastern Front (only 12 MC-202s, which managed 17 sorties in total), the mainstay fighter being the MC-200 which was clearly unfit for that theater.

Me-262 The design of the Me-262 started in 1938, while the new turbojet engines were in development by BMW and Junkers. Delays in the design were caused by development of the engines, but were finally ready for trials early in 1943. Full-scale production was delayed until early 1944, and the Me-262 first saw action in September of 1944 over Germany, and at this late stage of the war was used to defend against counter-invasion of the homeland.

The unconventional drives enabled the Me-262 to reach extremely high airspeeds, and it was the world's first true turbojet fighter. It was by the fastest aircraft around when it was introduced, while still retaining maneuverability (though not as maneuverable as propeller fighters), and was highly successful in its originally intended role of interceptor. The A-1 *Schwalbe* (swallow) with 4 30 mm MK 108 cannons and the A-2 *Sturmvogel* (albatross) with 2 30 mm MK 108 and a bombload are present in *IL-2*.

2.2.2 Ground-attack aircraft

He-111 The Heinkel 111 level bomber is present in the game as AI only. This twin-engine, middle bomber, together with the Dornier Do-17 (not in game) and the Ju-88, formed the backbone of the *Luftwaffe* bomber program at the outset of the war. Over 7,000 of the various types of He-111s were produced throughout the war. Although a fast bomber equipped with five defensive machine-gun positions that provide an extremely wide field of coverage, it by mid-war it proved to be rather vulnerable, requiring a large fighter escort wherever modern enemy interceptors are around. The H-2 model can select from a wide variety of bomb loads, and the H-6 model is capable of being equipped with two torpedos.

Hs-129 The Henschel 129 is based on the He-123, which successfully served at the outset of the invasions of Poland and France, and is "in effect a sort of flying armoured car" [1]. This dedicated ground-attack aircraft is heavily armored, and the in-game B-2 is equipped with light machine guns and cannons ranging from 13 mm to 30 mm, while the B-3/Wa *Waffenträger* (weapons carrier) can be equipped with a 75 mm cannon! This was necessitated by the increasing strength of armored ground targets. The B-series appeared in 1942 and the Henschel served through 1944, mostly on the Russian Front.

I.A.R. 81 The IAR 81 is the Romanian IAR 80 fighter modified to be a bomber. It consists of additional pilot armor and 6 7.62 mm machine guns, with the ability to carry bombs.

Ju-87 The Junkers 87 *Stuka* is possibly the most famous and recognizable aircraft of WWII. The word *Stuka* stands for *Sturzkampfflugzeug*, literally "dive-combat aircraft," what in English is called a dive bomber. The B-2 type became flyable with the version 1.2 patch, and the D-3 and G-1 types are AI only. This awe-inspiring machine struck abject fear into the hearts of many in the early parts of the war, not in small part due to the effect the wail of its diving siren had on those below. As the armament and speed of enemy fighters grew, it ceased being as feared as it once had, as many *Stukas* were lost due to their slow speed and relatively poor defenses. It nevertheless is a dangerous threat to any ground target, due to its highly precise dive-bombing attack.

Ju-88 This medium-sized Junkers bomber is another deservedly well-recognized aircraft. It proved itself to be the *Luftwaffe's* most versatile bomber, being capable of both level and dive bombing, reconnaissance, night fighting, close support and torpedo bombing. Although not all of these roles are fulfilled in the Ju-88 A-1 present in *IL-2* was constructed in 17 variants. Over the course of the war, more than 16,000 units of 10 different models were constructed.

The Ju-88, like the He-111 is vulnerable to attack yet not easily approached with its good rear field of fire. Like the Ju-87, its ability to dive bomb can make an attacking flight fearfully difficult to stop in time over the defended target.

2.2.3 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 small and highly versatile reconnaissance aircraft. The two-man "Stork" is equipped with a rear machine gunner, and its special aerodynamics allows it to fly at an extremely low operating speed of 50 kph and take off in 50 m and land in 15 m. It was present on all fronts and is able to carry out tasks of liaison, transport and even air-sea rescue.

FW-189 The Focke Wulf 189 A-2 *Uhu* (eagle owl), also known as *das Fliegende Auge* (the flying eye), is a light twin-engine aircraft specially designed for tactical ground reconnaissance. Its twin boom allows for a very wide field of view to the rear and is very stable at low speeds. It is equipped with a rear gunner and capable of carrying bombs.

Me-321 The Messerschmitt 321 is a glider transport built in 1941, having its roots in the plans of Operation Sea Lion, the proposed German plan to invade England. With a wingspan of 55 m and a maximum weight of 34,400 kg, this is a rather large glider at that! The *Gigant* was mainly used different units that were formed for special purposes and then disbanded.

Me-323 The six-engined Messerscmitt 323 is a monster of a transport, derived from the Me-321 glider. It served starting from the end of 1942 and was used in the Mediterranean and Eastern Front. The tremendous payload was put to good use supplying troops trapped in the Soviet counter-offensive of 1943. In *IL-2*, the Me-323 can be used to haul the Me-321.

2.3 Armament and loadout

The various armament and possible loadouts of all aircraft in *IL-2* are available in the in-game Object Viewer, together with a great deal of information about each aircraft and many objects (boats, tanks, etc.) in the game. Much information on armament and especially loadout is also available in condensed form at Sturmovik101, which was compiled by kajr and is hosted by Mudmovers. In addition, all armament and loadout information for the aircraft in *IL-2* (and Forgotten Battles as well) can be found in a well-made, third-party software program called Hardball's Aircraft Viewer. A list of current hosts can be found in this SimHQ thread, although that information will remain current indefinitely.

CHAPTER 3

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, take-off 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 [7]. 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* [8] 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.

3.1 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 take-offs, 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 is meant to help you in turns, as well as to tell whether you are turning. It is very helpful in trimming out the plane against slip, as well as holding the aircraft in a steady bank angle.

Manifold pressure gauge This handy but tricky gauge measures the pressure in the intake system of the engine. It is handy because it can be used as an indicator of engine power output. When the engine is running the engine creates suction in the intake, but with the throttle closed there is little pressure in the intake manifold, and the manifold pressure (MP) gauge shows a lower pressure reading. As the throttle is opened, it allows the engine suction to create a higher pressure in the manifold, so that the MP reading increases. The MP gauge can and should be used to set the throttle for a desired power setting. It is also useful for troubleshooting, since a damaged engine will not create as much suction, and so a lower MP reading than usual at full throttle indicates engine damage. You shouldn't want to anyway until it becomes 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, and none of them have 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.

3.2 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 [9].

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 3.1). 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

[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 3.1: German cockpit instruments

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 5.4 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.

3.3 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.

3.4 Checklists

We all forget. Checklists are there to help you prep your plane for flight and carry out simple maneuvers such as take-off, 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 preflight 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.

3.5 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, a bit faster than you can walk, although you will have to get a feel for safe taxi speeds through practice. The faster you taxi, the faster your airplane will become unstable. Keep in mind that you have to stay ahead of the airplane, as the hint at the very beginning of the chapter implies. Keep the stick well back while taxiing. This uses the elevator to help prevent the aircraft nosing over.

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, and this is what you use 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 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 take-off.

On the ground, steer with the rudder.

When taxiing, a number of forces created by the spinning propeller combine to produce torque, which causes the airplane to want to turn. If your propeller rotates to the right, the aircraft will want to turn to the left, and if the prop rotates left, then it wants to swing right. The tendency of the airplane to deviate from a straight path is called ground looping. Ground looping is also prevalent in taildraggers because their center of gravity is behind the wheels, so any movement to the side makes the aircraft want to turn. With sharp movements in taildraggers it is not hard to make them swap ends, which can be desirable if done purposely but usually is not. You will constantly have to use the rudder to counter ground looping while taxiing.

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

[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).

[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.

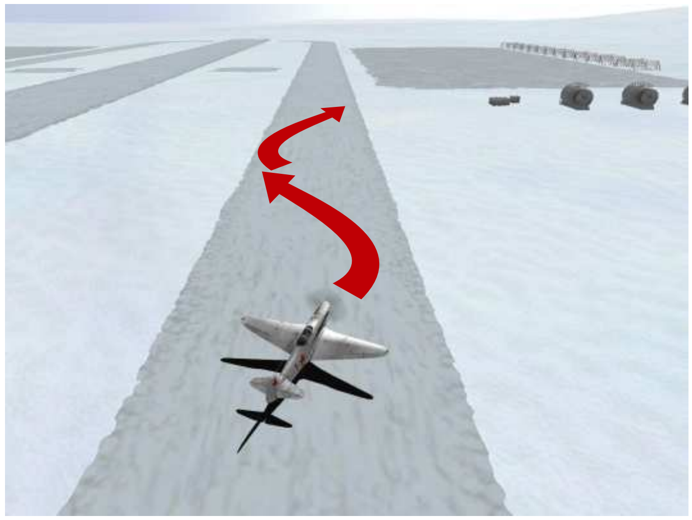

Figure 3.1: When taxiing, S continuously.

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 [10]: "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.

Few aircraft in the war have tricycle landing gear. These aircraft enjoy fairly good forward visibility on the ground. Of the flyable planes in *IL-2*,

Otherwise you can use the keyboard (B by default).

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] No pilot has ever failed to notice a big and obvious problem when taxiing taildraggers: the front of the aircraft. Namely, that it's blocking everything in front of them. In these planes you will have to be much more careful and taxi slowly. Normally you cannot detect anything directly in front of you, including parked planes. In a congested area, get someone to walk your wing—if you can find a volunteer! The only way to see what lies ahead of your path is to S continuously. To S means using the rudder to steer the plane left and right several degrees in order to get a quick view of what's ahead through the front quarter panel of the cockpit. You'll have to reverse the direction of the turn as you get closer to the edge of the runway: the resulting curved path resembles an S. When S-ing, use the brakes only intermittently. Scraping wings on the ground and nosing over are not as bad as plowing into someone in front of you, but they're still not desirable. Be careful to unlock the tail wheel before carrying out this procedure, and to lock it again after having started moving forward for take-off.

S continuously when you taxi.

3.6 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, so the thing is 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, although in a car we wouldn't talk about airspeed.)

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, respec-

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

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

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

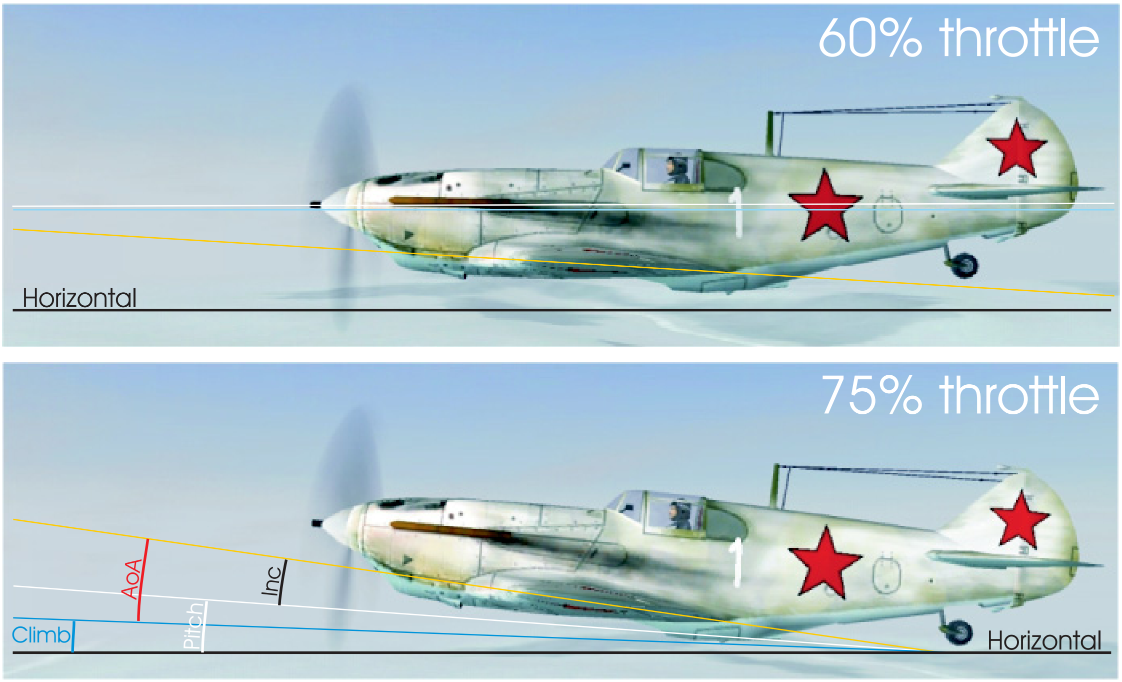

Figure 3.2: In the first picture, Oleg is flying his LaGG-3 in level flight (see section 4.5) at about 310 kph. In the second, he has smoothly added throttle and begun to climb. It is clear that the angles of pitch and climb have increased, although the angle of attack has not. The airspeed has not appreciably changed.

tively. 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 really 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 3.6, where a 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.” [8] 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 about to get 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 leading edge of the wing and the trailing edge of the wing; look closely at figure 3.6, 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 of this is when you change flap positions; see section 3.7).

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.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 nose of the LaGG is pointed slightly up and Oleg and his aircraft are climbing.[8] 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 directional lines determine 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).

[7] The only instrument in the Wright brother’s first plane measured angle of attack [8].

[8] 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.

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 it is pointed in just the same direction as the climb (this will be the case if it is climbing at a certain optimal speed), then the AoA will still be the same as it was in the case of level flight at cruise speed. In fact, this is probably close to the case in Oleg's climb in figure 3.6: assume that the angle of the 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 wings maintain their angle of attack and change the pitch of the airplane, converting the added power into altitude (see section 3.7). 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. Changing airspeed

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 4.3. 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 climb.

The majority of this discussion is parallel to [8], 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.

3.7 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 4.4 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?

3.7.1 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

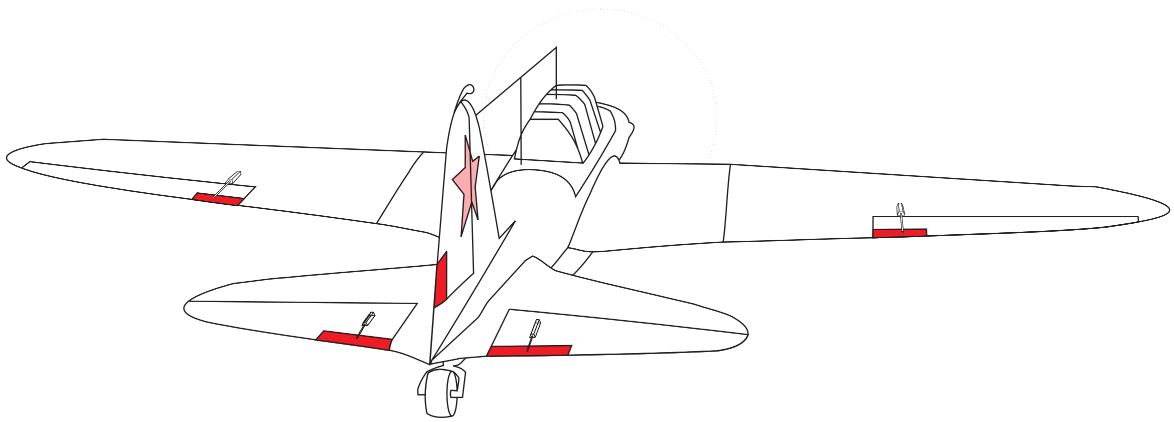

Figure 3.3: The Il-2 models have particularly obvious trim tabs, marked here in red. The hydraulic tab-operating systems are nicely animated, you can watch the aileron trim tabs from the cockpit.

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 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.

3.7.2 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 3.7.2. 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 3.7.2 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

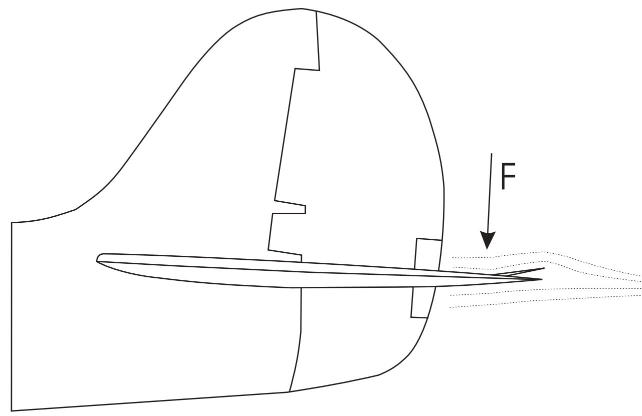

Figure 3.4: The effect of moving a surface on the elevator airfoil upward is a downward force on the airfoil.

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 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 9.8) 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 can read about phugoid oscillations in Denker's online book. 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 [8]: "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.

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.

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

Some planes do not have trim for all surfaces.

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.

3.7.3 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 take-off 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,[9] 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 4.3 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 has a maximum speed for the deployment of flaps. Unfortunately, for the time being you are left to

[9] 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* [11]. Many of these device designs are present in *IL-2*, but they are referred to collectively as flaps for simplicity.

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 9.2.2). 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 4

Flight

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

—*Aviation proverb*

Stop for a moment to consider all that you've reviewed so far in the last chapter: how to tell what is going on from the instruments and gauges; starting her up and getting in position for take-off, all kinds of theory about how to control airspeed, and about control surfaces. You'll surely want to actually go for a ride now. There are still a few topics that might interest you, such as how to actually take off and land, change direction and altitude while safely staying up in the air. Then it's a cinch to find your way around the sky and gently become reacquainted with the tarmac.[1]

4.1 Stalls

There's an aviation adage that says take-offs 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 big factors that commonly determines which of these two types of landings you end up with

[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.

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 other chapters. Another important phenomenon that probably causes more virtual deaths than enemy fire and is directly related to stalling is the spin, which really is a special kind of stall, and is covered in section 4.9. Right now it's important to understand what a stall is. It will prove very useful in later discussions about take-off, landing, and combat maneuvers.

Let's again picture an aircraft in level flight at cruise speed, as in section 3.6 about angle of attack. Suppose that the pilot, whose name is Amelia, is feeling adventurous and would like to find out just how slow her aircraft can fly while maintaining altitude. Having read about AoA, she reduces throttle and, in order to prevent the aircraft from descending, pulls back on the stick a bit. Pulling on the stick increases the pitch, and since the aircraft is still not changing altitude the the angle of attack increases. The resulting increase in lift is enough to prevent the aircraft from descending, and the corresponding increase in drag slows the aircraft. Amelia dials in some nose-up trim, and then decides to close the throttle considerably. To keep the aircraft level, she'll now need to continue to pull back on the stick. The AoA thus increases, increasing lift and drag. In fact, the forward view is now reduced because of the nose-up attitude. She manages to maintain altitude, and sees that the aircraft has slowed to a crawl. What's more, she hears a rushing sound, feels quite a bit of vibration in the stick, and notices that the controls have gone "mushy," not responding very easily to her control inputs.

Amelia is not satisfied. She *knows* that she can fly slower. She trims out, reduces the throttle still further, and continues to add back pressure. All of a sudden, the aircraft gets an idea of its own, and drops its nose sharply. What happened?

Recall that the angle of attack is the angle between the chord of the wing and the direction of the relative wind. It produces lift in large part due to the way the air flows around it. As the AoA increases, the air on the upper part of the wing can no longer flow smoothly, and begins to detach itself from the wing and flow turbulently. This results in less lift gain than normal and more drag, and only gets worse with increasing AoA. Beyond a certain AoA, an increase in AoA actually results in a reduction of lift and a significant increase in drag. This AoA is called the *critical* angle of attack. Nothing magical happens at this angle, but once the wings get up into this region of AoA, a sudden reduction of lift may occur, causing the weight of the aircraft to drop the nose—as long as the center of mass is in front of the center of lift![2]

For our purposes, the stall is the condition that the wings are in, and not the dropping of the nose, which is the reaction of the aircraft to the stalled condition of the wings. The nose drop can rightly be called a stall, but other reactions can also result from a stalled condition as well. If you try to repeat Amelia's experiment in *IL-2*, you'll notice that it doesn't happen the way it's been described here. In that experiment, the wings are at equal angles of attack, and stall together. If one wing is at a higher AoA and stalls before the other, which may occur if the aircraft is yawing, there is wind, in a bank angle, and so on, then the wings introduce a rolling motion on their own. At the critical angle of attack, roll stability begins to disappear, meaning that the wings may continue or even accelerate on their own. The result is that the stalled wing drops. For reasons we won't speculate on here, the *IL-2* flight model nearly always drops a wing in a stall instead of or in addition to dropping the nose; it seems nearly impossible to get the nose to drop straight on. This is again mentioned in section 4.9 in the footnote on page 84.

So the lesson here is that Amelia cannot fly just as slow as she wants, because her aircraft will stall out, right? No! The lesson is that at high angles of attack, the wings will actually start to lose lift instead of gaining it. This is not simply due to low airspeed, but rather *directly* due to angle of attack. Note that well:

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

Airspeed can play a role, insofar as it affects angle of attack: because of the reduced air flow, lower airspeeds require a greater AoA to produce the same amount of lift as at higher airspeeds. You can continue to "fly in a stall" at high angles of attack greater than the critical angle,[3] but you cannot continue to fly at airspeeds lower than the stall speed without giving up altitude. Beyond the critical AoA no additional lift is available to maintain the vertical equilibrium (fighting gravity), so the aircraft will begin to descend or, if loss of lift is dramatic, accelerate downward, and control of the airplane can even be lost. Sound scary? It can be without enough altitude to recover, and at any rate it's not usually exactly productive in a combat situation.

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[2] This is actually important in aircraft design, otherwise it becomes quite difficult to recover from a stall.

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

The implication that stalls are a function of AoA is that *stalls can occur at any airspeed.* If in a high-speed turn the pilot pushes the wings into a sufficiently high angle of attack, the aircraft will stall just as at lower speeds, with the exception that the stall will usually be accompanied by a much more violent wing/nose drop. This can occur in any position and during high-speed maneuvers. Fortunately, pilot strength is often insufficient at high speeds to pull the stick hard enough to drive the wings into a stall, but this is no guarantee. Due to wing and aircraft design, the way the wings are loaded, the stall characteristic of each plane is different. Some aircraft are easier to stall than others, some react less violently, and some are easier to recover than others. It is very beneficial to thoroughly acquaint yourself with the high- and low-speed stall characteristics of each aircraft that you fly into combat.

Logically, stall recovery always involves allowing the wings to unstall. Often it is sufficient to simply relax back pressure on the stick to prevent a nose/wing drop or to unstall the wings. If back pressure is not relaxed in a high-speed stall, a spin is likely to develop (see section 4.9). Deep stalls can be difficult to recover. Stall recovery procedures typically involve reducing throttle and neutralizing the stick and rudder. The aircraft should be allowed to build up speed in the nose-down attitude before recovering. Trying to recover too quickly can result in a second stall. If recovering at critically low altitude where the aircraft cannot be allowed to simply dive, be very attentive during the pullout to indications of a stall: the buffeting sound and, if you have a force-feedback stick, vibration.

4.2 Energy

Have you ever read something to the effect of, “When you’re fighting, you’ve got to keep your E.” E stands for energy, but what does energy do anyway? As it turns out, energy doesn’t *do* anything, energy *is*. You can think of it as something your aircraft has. Understanding the energy your aircraft has and in what forms is key to controlling the 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 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 [8]. 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, with the help of the propeller, can overcome the aircraft's inertia to convert fuel into the other forms of energy, namely airspeed and altitude. But let's not get into inertia.

4.3 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

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

in one form of energy to gain another, and paying the rent (what a drag). In fact this is so related to energy, it is really an extension of the previous section. And since the airplane changes energy states at a given rate, we are talking about the power involved.

This has already been emphasized in section 3.6, 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 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 or descend at a given rate you have to watch your airspeed, which you will of course control with angle of attack (i.e., stick and trim) and throttle setting.

The idea of trimming for angle of attack, which essentially determines airspeed,[5] is very important to keep in mind when making changes in airspeed and altitude. We have gotten out of our minds now the concept that the stick is the up/down control for the airplane, and that the throttle controls airspeed. This misconception is due to the fact that it seems to work in most conditions. Actually, it would also be wrong to the the other way around—that the throttle controls up/down and the stick controls airspeed. Controlling altitude and airspeed requires manipulation of both.

In this sense, the pilot has to be aware that he can't generally follow a fixed set of rules for changing altitude and airspeed, neither for the stick nor the throttle. For example, being high and slow is very different from being low and slow: you wouldn't make the same adjustments in one situation as the other. This means that a rule such as, "If you are slow, do this," cannot always be right. We'll talk about this some more in the section on the power curve.

To get a feel for how changes in airspeed and altitude can "normally" be made, let's now look at 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 commanding officer understands calls for a change of heading and an altitude of 2800 m. For simplicity let's say that you turn first and then climb. Once on 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:

[5] Angle of attack determines airspeed 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.

- 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 3.6, 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.

Which is better? In this example situation the first possibility could bring your airspeed dangerously low. 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 cruise conditions you are not at full power and can increase your power setting to climb.[6] It would be a great idea to vary the angle of attack with the stick (and trim out to relieve pressure on the stick) 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 closer to the maximum rate of climb. This airspeed is called V_y, and as it turns out is just a little bit slower than optimal cruise speed. (Don't worry, you haven't missed any discussion about how airspeed affects climb rate.) If in the example you were cruising at 340 kph and the airspeed for optimal rate of climb were 260 kph, then you might actually pull the nose ever so slightly up, add power and settle into 260 kph, making small pitch adjustments with the stick and trim to keep the airspeed at 260 kph.

Let's say that you're flying alone and have noticed you are about to hit a cloud you'd prefer to fly over. You don't have enough room left to climb at optimal climb rate. Instead you need to gain as much altitude in as short a distance as possible. As before, pour on the power but steepen the climb. To do this hold the stick back even more than before and trim off, until you in a

[6] Throughout this discussion throttle is spoken of, but rpm may need to be changed with throttle if the propeller system is being manipulated for cruise settings.

steady climb at an airspeed that corresponds to the optimal gain of vertical meters per horizontal meter. This airspeed is called V_x and corresponds to the maximum climb angle. This won't get you up as *fast* as optimal climb rate, but gives you a better chance of getting over that cloud with the distance you have.

Let's briefly revisit trying to change altitude using stick alone. In a zoom climb (trading airspeed for altitude), the steeper the pitch of the climb the faster you'll trade airspeed for altitude, the limit being a purely vertical climb. Make sure you understand the distinction from a steady climb. You can trade in excess airspeed for more 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. At some airspeed you won't be flying anymore.

In any case, whether you zoom climb or climb with a steady speed, be it quickly or steeply, you should use the stick and throttle to start leveling off before you reach the new altitude to prevent overshooting it. Of course you'll need to close the throttle if you want to resume your previous cruise speed. It's worth noting that if you simply reset the throttle to the cruise setting while leveling off you will need a lot of forward stick pressure and it might take a while for the aircraft to settle into the cruise speed. Instead you can close the throttle further than the cruise setting and let the nose drop in order to make the change in climb rate more quickly with less stick pressure, then open the throttle as you level off to resume cruise speed at your new altitude.

If the climb is long enough to warrant using trim (to relieve pressure on the stick and hold the climb steady; your 300 m climb might not be enough to bother), be sure to trim the nose back down for cruise. The reason you need stick control in all cases is explained in Denker's section on phugoid oscillations.

Examples are well and good, but it is more beneficial to understand what is going on, and how to expect the aircraft to react in different situations. We'll have to bring drag and airspeed into the picture, and look at classic ground-school material. The following discussion is adapted from section 1.2.5 and chapter 7 of Denker's *See How It Flies*. His online book provides a much more thorough explanation and many more concepts.

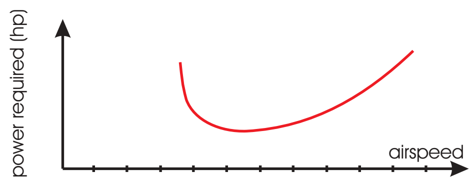


Figure 4.1: The power curve illustrates the power associated with airspeed. This power is related to drag and can be expressed in terms of propeller power output.

4.3.1 The power curve

So far in our discussion about changing altitude and airspeed we've considered an example where we are travelling at 280 kph. In the warbirds you'll be flying this is well above stall speed, though not so high that you don't have to pay some attention. Lose 100 kph and you'll have to start being pretty careful. The airspeed at which you are flying places a requirement on the amount of power you need to maintain altitude, and this changes the way that you'll want to make adjustments to airspeed and altitude.

How much engine power do you need to fly level at 280 kph? What about 380 kph, and what about 180 kph? What effect does airspeed have on climbing? The best climb rate and cruise speed, the amount of power needed to fly at faster speeds—all of these are of course related to moving through the air and giving away energy every second. In other words, your aircraft is dissipating power due to drag, paying the rent. The amount of rent we have to pay depends on airspeed, but not in a simple way. I'd bet it makes sense to you that flying faster requires more power from your engine, because the force of drag is higher. As you slow the aircraft, you need less power to maintain level flight. But if you continue slowing your aircraft down, you'll begin to need more power again! To support its weight at low speeds, the aircraft needs a high angle of attack, and the associated force of drag is also high.

Figure 4.3.1(a) illustrates the amount of power at various airspeeds this is required of the propeller to keep the aircraft in question in level flight. Because it shows the power required, this curve is called the power curve; we could also call it the power-required curve. Notice that the curve goes up both for high and low airspeeds. If you keep in mind that the curve represents the power required to maintain level flight, it also becomes clear that at any airspeed there is some minimal input required from the engine to offset drag. (Actually, a significant updraft could also provide the required power.) Essentially, this figure indicates for us how much drag is present

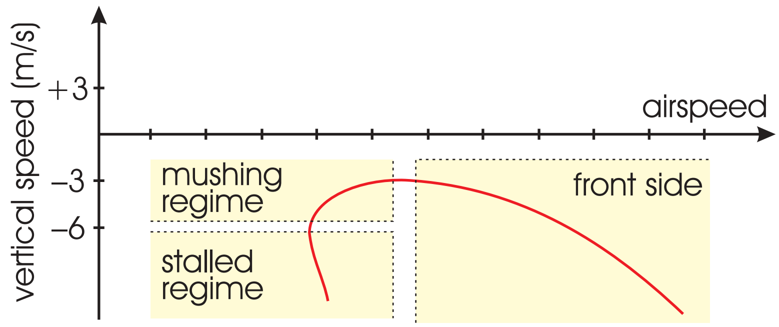


Figure 4.2: The power curve can also be expressed in terms of vertical airspeed. This curve represents an idling motor, essentially zero power output, so the aircraft can only descend. The three different regimes of flight are labeled.

at various airspeeds. Although we won't do this, comparing this figure to a second curve showing the power available from the engine would show us the range of airspeeds we could choose for level flight.

An alternative, very practical representation of the power curve is shown in Figure 4.3.1. The only real difference is that power is no longer expressed as power required to maintain level flight, but rather the rate at which potential energy in the form of altitude is being lost. So the curve is basically inverted and you can read the vertical airspeed (rate of climb or descent) in relation to the airspeed. This curve will shift up and down depending on how much power is being supplied. Supply more power and the curve will shift upward, meaning you get a higher rate of climb for the same airspeed. The curve shown in the figure represents an aircraft with the motor idling, so there are no airspeeds at which the aircraft can climb.

In the figure there are three different regions marked: the "front side" of the power curve, the mushing regime and the stalled regime. Usually we think of flight on the front side of the curve, where we have a comfortable excess of airspeed. However, often enough—notably on landing approach and during low-speed combat maneuvers—a pilot will need to fly on the "back side" of the power curve, corresponding to an increasingly high angle of attack, and he or she needs to be aware of what happens. There is an enormous amount of drag involved and the airplane will not respond as it does on the front side of the curve. Low altitude is the last place you want to be surprised by the back side of the power curve. Practice low-speed maneuvers at altitude!

4.3.2 Applying the power curve

At the top of the power curve, defining the boundary between the the front and back sides of the curve, there is an airspeed where drag on the aircraft is at a minimum. It is clear that at this airspeed you will get the minimum rate of descent, or minimum sink—after all, the engine is at idle. This will give you your best endurance glide. If we add power from the prop, this airspeed will provide the maximum climb rate. As mentioned earlier in the section, this airspeed is called V_y. A typical value for our warbirds is 160 knots, or about 250–260 kph. The actual value of V_y can be lower or higher depending on the drag on the aircraft, including the airframe and especially the wings, which are what determine the shape of the power curve. If you have the flaps lowered you will never get the best rate of climb, because you have introduced too much drag. Also note that the curve is fairly flat on top. If you are off V_y by just a few kph, your climb rate won't vary drastically.

Think back to climbing over that cloud, or clearing an obstacle at the end of the runway. The power curve also helps us understand the best angle of climb, V_x. If you slow down just a bit from V_y, you will not climb at the best rate, but your slower forward airspeed will help get you higher over a shorter distance. If you slow down too much though, you can quickly find yourself not getting much climbing done and approaching the stalled regime. Lowering flaps one notch might well help you get a better angle of climb.

The same principle applies of course for descent. If you are too high close the airfield with the intention to land, it is not at all necessary to make a nuisance of yourself by diving and dangerously building up speed where there is air traffic. Let's assume you are on approach and find yourself too high—on approach you certainly don't want to dive. The best way to increase your descent before getting too close to the airfield is to increase drag without increasing airspeed. Let's suppose you're already at idle. If you're on approach and too high, you might already have extended your gear and flaps. Nosing over would help increase your rate of descent, but it will also increase airspeed (and possibly damage your flaps). What you can do is put yourself at a lower airspeed, where there is more drag. Keep the throttle at idle and the nose *up,* allowing your airspeed to fall into the mushing regime while staying above the stalled regime. This will increase your rate of descent.

4.3.3 Low and slow

Thinking of this behavior in terms of drag also helps us understand why flaps are used for take-off and landing but not for climbing. We need to land at low speed, and at take-off we'll take all the speed we can get, although it's usually not very much. So in these inevitable situations we are in the typically fearful position of being on the back side of the power curve near the ground. This is where flaps can come in handy. Although they increase drag, flaps also lower the stalling speed and permit stabler flight at lower airspeeds. When taking off, the landing flap configuration produces too much drag for climbing, so we raise the flaps a bit to decrease drag. If the aircraft is not heavily loaded and the runway long enough to build up speed, flaps are often not required at all.

Even with flaps, being at low airspeed and low altitude carries an inherent potential danger: a loss of airspeed is difficult to overcome because you have no spare altitude to cash in to get more airspeed. If the airspeed is allowed to drop into the stalling regime, it's entirely possible to get into a situation where a snap roll, spin or unrecoverable roll results in a crash. This has to be carefully guarded against, especially during take-off and landing procedures, when the pilot has a high workload.

The key to staying safe at low altitudes is to know the safe speeds at which to fly, and to avoid action that will cause the speed to get dangerously low. Knowing the safe speed includes thinking about flap configuration and how heavily the aircraft is loaded. A typical mistake is to pull back on the stick in order to increase climb on take-off or to reduce rate of descent in the landing approach. This will be discussed a bit more in the appropriate sections.

Stalls can occur at any speed, but are more likely at low speeds. Steep turns will bring the inside wing into a stall condition at higher speeds than straight-on flight, so be careful with these at low speeds. It is especially important to make coordinated turns at low altitude. You can get away with ignoring the rudder at cruise speeds, but the yaw component in improperly coordinated turns at low speeds help to create spin or snap-roll conditions. Furthermore, it can be dangerous to make quick throttle changes at low speeds and altitudes, because the sudden adverse torque can cause a stall. However, this does not seem to be a great danger in *IL-2*.

4.4 Take-off

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 take-off now, would it?

4.4.1 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 (hopefully in time) that your plane doesn't want to roll straight ahead, just as it does during taxiing. Remember that this side-to-side turning movement you've come to learn is collectively called ground looping. On take-off is principally due to helical propwash and, at the point where the plane's tail raises, gyroscopic precession.[7] Smoothly advancing the throttle greatly helps to reduce severe ground looping. However, the airplane will want to turn, so you must use rudder to keep the airplane straight on the roll-out. (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 the less you need to hold the rudder down. Now if the plane starts heading too far to one side, use more, but be careful not to overcorrect; you need to use lots of rudder on

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

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[8]—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, because the tail will start to stay up on its own, and you don't want to nose over. 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 [9] 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. More on this in the next section.

The best way to learn the roll-out is to practice slow take-offs on long, paved airstrips to allow for long roll-outs. Advance the throttle slowly and practice holding the aircraft straight on, and let the tail come off the ground gradually (in taildraggers). As you get more experience with your feet (assuming you have rudder pedals) you can advance the throttle more aggressively, get the tail up more quickly, shorten your take-off run, and use soft fields.

4.4.2 Rotation and climbing

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 rolling 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. As has been emphasized, you are on the back side of the power curve at low altitude. Once the aircraft is rolling with enough speed to get airborne, you can back a small amount on the stick to increase the angle of attack and provide more lift. This makes the slight transition from ground airspeed to a climbing attitude. This act of lifting the nose in order to initiate a climb is called "rotation." Actually, once you have reached take-off speed a properly trimmed airplane will take itself off without further pilot input. All you are doing with rotation is to use the extra airspeed you have built up to make the transition to a climb

[8] You P-39 jocks just pretend you didn't read that.
[9] about twelve degrees' worth [8]

when you want. What you do *not* want to do is initiate a zoom climb! A powerful aircraft with an excess of airspeed can literally leap into the air, but only experienced pilots should undertake such maneuvers. You can only successfully zoom climb when you have excess airspeed, and normally there is precious little of that just during take-off, so use back pressure on the stick with moderation. Pulling back too hard will dump your airspeed, bringing on a stalled condition. You're likely to find yourself unable to recover before you return to your original altitude—the ground!

Powerful and light fighters can do acrobatics quickly after take-off, but don't get ahead of yourself. 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 (see section 4.3). If you don't know this airspeed for your aircraft, a good guess is 260–300 kph. If heavily loaded, V_y will be higher. The angle of attack corresponding to V_y will keep the airplane at the best climb rate and allow the excess engine power to be translated into gained altitude. Once you have altitude and are in a steady climb, you can power back to climb power, unless you are scrambling or are one of those pilots who flies everywhere on full throttle.

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 stay on the back 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.

4.4.3 Use of flaps

The airfields in *IL-2* are generously long, and under many conditions flaps are not required for take-off. However, situations might arise in which you only have a limited length of the strip available to you, the field is soft or bumpy, or you have to clear an obstacle at the end of the runway. Load factor also plays a big role on take-off, meaning when you are heavily laden with bombs, fuel, ammo, your ground crew (when evacuating Stalingrad), etc. In all of these situations, it is advantageous to deploy flaps to help stabilize the aircraft at lower speeds. This means that you can rotate (lift the nose) at a lower airspeed, so you need less runway to get airborne. The flaps will also increase V_x, so that you get higher in less horizontal distance. Yet another reason you might use flaps, even on a long smooth runway, is to improve forward visibility. Since the flaps change the angle of incidence, you get the required angle of attack for taking off at a lower pitch angle, and can see better faster. This is especially true for taildraggers.

There are a couple of important things to observe when using flaps on take-off. First of all, don't forget to raise them at some point! You'll notice if you don't, because you won't be able to climb or fly very fast. And if you do manage to fly fast, you might jam the flaps. But even more important is to avoid that rookie mistake of raising the flaps without having built enough altitude and airspeed. Leave the flaps in their deployed position, and get at *least* 100 m of clearance before you raise the flaps. More altitude is certainly better before raising flaps. When you do raise the flaps, raise them one notch at a time and keep some back pressure on the stick to prevent the nose from dropping too far. Don't worry, having raised the flaps you've removed all that drag, so have just a little patience: your airspeed will build up pretty soon. It's true that you could get airspeed back more quickly by letting the nose drop, but you're likely to drop faster than you want to. The common rookie mistake is to raise the flaps, see the nose drop and notice that you're descending quickly toward the ground, and pull back too hard on the stick to keep the plane in the air. In no time this sharp pulling back on the stick at low airspeed leads to a stall and a dropped wing, and finally the resulting crash report—filed by the ground crew. So remember, raise the flaps one notch, keep full power on, anticipate the nose drop and keep the nose from dropping too fast. After stabilizing, raise them another notch, and soon you'll be climbing steadily.

4.5 Level flight

Level flight means flying straight ahead, without gaining or losing altitude. Although the airplane will fly itself if you just release the controls, achieving and maintaining perfectly level flight is a difficult task to undertake, even in a simulator where you don't have to deal with updrafts, and there typically is no wind or turbulence at all. Not many pilots are enthusiastic about taking time to train sustaining level flight at a required airspeed, but the value of this lesson is not to be underestimated. This is war; flights of fancy are not the order of the day, and disciplined, precise skills are required to advance to being a useful pilot. The skills you develop learning to fly level and straight on are fundamental to other maneuvers. For this reason, maintaining level flight at various airspeeds is to be considered the first skill a pilot must master. Do not move on to other topics until you are able to do this. Precise level flight also becomes invaluable in navigation and formation flying.

Of course the key to level flight is making the proper adjustments of stick, trim and throttle. Remember that no one control affects only altitude or airspeed. Changing pitch and setting the trim controls AoA and thus influences airspeed, but can also cause changes in altitude. Changing the power (throttle and propeller setting) helps adjust the rate of climb, but can also be used to influence airspeed. These concepts were introduced in section 3.6 on page 33. Let's review the coordination of these controls by looking at some specific situations. Recall that your stick is a primary flight control. In all cases you first use the stick to initiate changes in AoA, and then trim off the pressure once the new angle is established. When learning and flying alone you should always make smooth changes in both stick and throttle, and carefully observe the effect they produce.

Case 1: too slow You are maintaining altitude, but can't seem to keep speed. You cruise at a higher speed you need to reduce the angle of attack, but to prevent your aircraft from losing altitude you also need to increase power. So, like Oleg and his LaGG, you add power and push the nose down. Then trim to the new setting so you can relax pressure on the stick. The trick is to do this in such a way that the plane stays at the same altitude. It takes smooth control and practice.

Case 2: too low If you are in level flight at the right airspeed but are too low, add some power. This alone may not solve your problem though—if you only add power you will end up in a phugoid oscillation. You will begin to climb, and should use your stick to damp any oscillation in the climb by keeping the airspeed constant in the climb. Once you are almost back to altitude, reduce throttle to the previous power setting and use the stick to transition back into level flight at the newly acquired altitude. Since you were trimmed to the correct airspeed before and have returned to the same power setting, you will not need to retrim.

Case 3: too low and too slow You find yourself flying level, but too low and slow. As in case 2, add power. This time, however, you will want to push the stick forward so that you accelerate to a good climbing speed before initiating the climb to the desired altitude. Then level out as before, but don't throttle back to the previous power setting. Similarly to case 1, you were too slow before, so you will need to keep some of the power you added for the climb. Adjust throttle and stick together to find the right equilibrium.

Case 4: too high This often happens when you overzealously apply power and/or have your nose trimmed up too high. The solution is obvious: reduce power. However, it important to control your descent by not letting the pitch drop too far. This is especially a problem if you make a drastic reduction of power. In this case, you may need to apply back-pressure to increase AoA so that the airplane does not pick up speed in the descent. When you have descended down to almost your goal altitude, gently add throttle to the previous power setting, and use the stick to control your transition to level flight at the new altitude. As in leveling out of a climb in case 2, since you were trimmed to the correct airspeed before and have returned to the same power setting, you won't need to retrim.

Case 5: too fast If you are flying level but too fast, you can reduce speed by applying back-pressure on the stick and thereby increasing angle of attack. This of course will cause you to zoom climb. To prevent that, reduce power with the throttle and then prevent yourself from descending by increasing back-pressure. Find the necessary AoA with the stick and adjust throttle until you settle into the new speed, being careful not to change altitude.

Case 6: too high and too fast If you are in level flight but discover that you are above altitude and going too fast, then there is no doubt that you need to reduce power. Simply combine the procedures from cases 4 and 5 to achieve the desired altitude and airspeed.

Case 7: too slow and too high In this case you can trade the excess altitude for some airspeed by nosing over with the stick. However, it is likely after you have descended to your goal altitude and are transitioning to level flight that you will have to alter AoA and throttle. This depends on why you were too high and too slow.

Case 8: too fast and too low As in case 7, here you can exchange forms of energy, this time by zoom climbing. Again, depending on why you were in this position, you will probably need to adjust AoA and throttle to achieve level flight at the new altitude.

Case 7: undesired climb or descent You often find that you are at a good speed, but unexpectedly climbing or descending. This is simple to remedy: make a power change. If you are climbing, the correct response is to throttle back. If descending, power up. Do not try to get rid of the ascent or descent just with the stick, as this will introduce a new problem of changes in the airspeed. (It takes some experience to learn for a given aircraft how much change in power is required to counter the vertical speed.) As you transition out of the climb or descent, you will notice that you are either too low or too high, and you should continue with the measures described in case 2 or 4. If during the correction variations in airspeed are also incurred, you will need to apply the methods for the appropriate case as described above.

The main indicators you need for these corrections are: the position of the nose relative to the horizon, or an artificial horizon in the absence of a visible horizon, the airspeed indicator and the altimeter. Don't rely too much on the vertical speed indicator, since it reacts more slowly than the altimeter and the horizon.

Once you have settled into level flight you will have to keep movement about all three axes in equilibrium in order to maintain level flight. (For more on settling in after changes, see again Denker's section on phugoid oscillations.) This can take some concentration, but soon you will learn to quickly notice deviations from level flight and how to make slight, smooth changes to correct.

It is important to note that at various speeds you will need to adjust rudder trim to prevent movement about the yaw and roll axes. There is a certain airspeed at which the rudder will counter rotation around the yaw axis, and this is generally designed to be in the area of cruising speed. For other airspeeds, the rudder will no longer provide the force necessary to counteract rotation and has to be adjusted. The happy pilots with rudder trim can relax this pressure, but those without—for instance Bf-109 jocks—will get a leg workout.

4.6 Turns

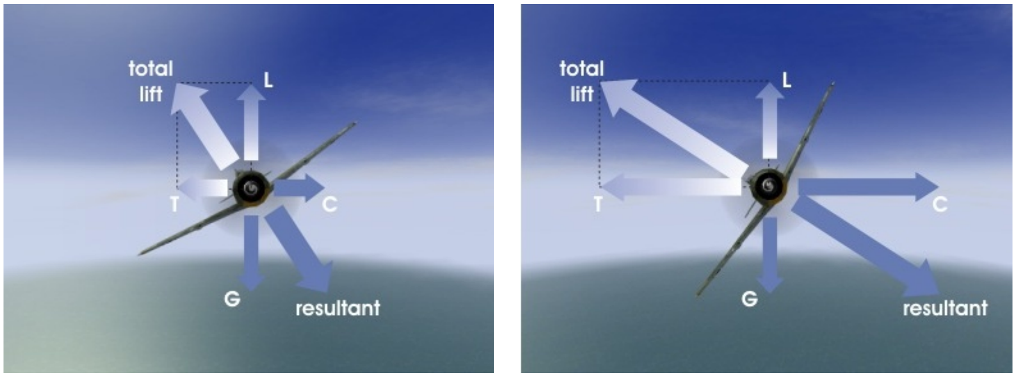
Combat maneuvers require a lot of hard turning, often using both the horizontal and vertical planes of movement, and combat aircraft are equipped to deal with these stresses—better even than the pilot. How and when to make turns in the context of combat maneuvers, as well as the parameters involved in turn performance and different types of turns, are discussed in chapter 6. For now, we begin by considering the required control inputs and forces involved on the aircraft during horizontal turns. In learning these you will better understand the process of turning and its implications on aircraft performance, which is so crucial during air combat.

4.6.1 Horizontal turns

As everyone who has observed a turning airplane knows, an aircraft is turned by rolling it into a bank angle. The roll is performed using ailerons, so the pilot deflects the stick in the direction of the turn. The turning aircraft will inscribe an arc (a segment of a circle) through the sky as long as the aircraft remains in its bank angle. Once the aircraft is rolled into the bank angle, the aircraft's roll stability will hold it there and aileron deflection is no longer needed, so that aileron control on the stick is no longer required. There seems to be something in the roll stability of the *IL-2* flight model that requires some aileron input to be held during a turn, so you will have to learn to hold the aircraft in the desired bank angle with the ailerons.

Actually, use of the ailerons is not the only required control input. The aircraft is turning because its wings are pushing it along the path of the circle. However, if only ailerons are used during placement of the aircraft into a bank angle, the aircraft will yaw. Because the wings are pushing the aircraft in the horizontal plane, the aircraft is suddenly no longer pointing in the direction it is moving. This is experienced by the pilot as being forced to the side in the cockpit, and measured by the ball moving out of the center on the turn and bank indicator. To compensate for this adverse yaw, the pilot should coordinate the transition by applying rudder in the direction of the turn. How much rudder? This depends on the aircraft. In the aircraft of *IL-2*, the answer is usually, "not much." As the bank angle is beginning to be established, the rudder pressure should be released, or the aircraft will yaw in the other direction.

In level flight, the lift vector compensates the downward force caused by gravity. As the aircraft is rolled into a bank angle, the lift vector, being created by the wings and perpendicular to them, is no longer applied only in the vertical direction; it now has a horizontal component as well. This horizontal component is what is causing the aircraft to turn in the horizontal. However, this means that the vertical component of lift is no longer equal to the gravitational force, so the aircraft will start to accelerate downward. To prevent this, the total lift must be increased, so that the vertical component remains equal to the gravitational force. In order to increase the total lift, the pilot adds back pressure with the stick, using the flippers (or elevators) to increase the wing's angle of attack. The back pressure should be smoothly



Shallow bank Steep bank

Figure 4.3: Forces involved in a horizontal turn

applied at the same time as the ailerons and increase with the bank angle. The back pressure must also be maintained throughout the turn, since the additional lift is required as long as the aircraft is in its bank angle.

This is illustrated by Gunther, who is flying the Focke Wulf in figure 4.6.1. He is seen making a horizontal turn to his right using two different bank angles. Six force vectors are drawn: the gravitational force G and the vertical component of lift L opposing it; the horizontal component of lift T that is turning the aircraft and the centrifugal force C according to the laws of motion; and the total lift force and the resultant force. As can be seen in the figure, the total lift force is the sum of L and T, and the resultant force is the sum of G and C.

In the shallow bank angle, about 37°, the horizontal turning force T is relatively small. The aircraft will therefore turn at a slow rate along an arc of large radius. In addition, the total lift force required is not much greater than the vertical component of lift L, so not much extra lift is required of the wings and little back pressure on the stick is required. The resultant force, equal to the total lift, is not much larger than L.

In the steep bank angle, about 60°, the turning force T is much larger. The aircraft will be turning at a much faster rate along an arc of smaller radius. Because the aircraft is banked so steeply, the total force required of the wings in order to maintain altitude is quite large, and a rather large stick back pressure is required of the pilot. The resultant force is approximately twice that of L.

These simple observations raise some questions. One obvious one is, how much back pressure is required in the turn? In general, you can use the position of the nose relative to the horizon to tell whether your the attitude is correct and you are gaining or losing altitude in the turn. The nose should be only a few extra degrees higher than normal, depending on the bank angle. You can also use the attitude indicator (artificial horizon) if you have one to check attitude. Another excellent way of correcting is to look at the altimeter. Here the *rate of change* of the altitude is important. The faster the needle is increasing or decreasing, the more adjustment in pressure is required. However, if the aircraft is in a severely nose-down position and steep bank angle, do not try to correct the turn by applying more back pressure. This corresponds to the conditions of a spiral dive. Instead, reduce throttle and roll the wings level, then apply back pressure to return to level flight.

Another question is, how can this turning force be measured, or, what is a measure of turning performance? The downward vertical force component G is always due to the acceleration of gravity acting on the mass of the aircraft.[10] The turning force T is due to the centrifugal acceleration. The acceleration due to gravity (9.8 m $/s^2$) can be taken as a standard and expressed as one G unit. The acceleration of the aircraft is the same acceleration of the pilot. Since the mass of the aircraft and the mass of the pilot are quite different, so are the forces—thank goodness! Therefore, it is the acceleration that the pilot feels. A turn in which centrifugal acceleration is three times that of gravity is called a 3-G turn. Gunther's steep turn of about 60° is a 2-G turn, so the poor guy feels as though he weighs twice as much as normal.

Definition of G

This acceleration works on the blood too, pushing it toward the lower end of the body. At high-G turns, the eyes don't get enough oxygen from the blood, the cones in the retina stop functioning properly and the pilot's vision greys out and may also black out. After prolonged or very high-G turns, the brain can't get enough oxygen due to the lack of blood flow and the pilot can pass out. This is called G-lock and can last many seconds after the high acceleration is reduced. The dangers to a pilot in G-lock are obvious.

The increase of angle of attack that provides sufficient lift to both turn the airplane and oppose gravity also increases the drag. This means that *the aircraft wants to slow during the turn.* As Gunther has shown, the steeper the turn the greater the increase in required total lift. In very steep turns the aircraft will tend to slow down dramatically. To maintain airspeed during the turn, the pilot should open the throttle to increase engine power. There is a maximum maintainable airspeed for a given turn performance, at which the

[10] According to a certain Isaac Newton, force is mass times acceleration: $F = ma$.

entire thrust of the engine is being used to overcome drag. If the turn performance is increased beyond this, airspeed will decrease. In other words, if the pilot is turning hard with the throttle fully open and the aircraft is losing airspeed, the pilot will either have to accept the loss of airspeed due to the increased drag the turn imposes on the wings, or else reduce the turn rate. Alternatively, the pilot can allow the aircraft to descend in the turn, trading in altitude to maintain turn performance and airspeed. Such a turn is called a gravity-assisted turn.

In extremely steep turns approaching 90°, the aircraft will no longer be able to produce enough vertical lift to overcome gravity. In such steep turns the nose above the horizon can be raised to assist. However, this will not be enough to overcome gravity, and the aircraft will lose altitude.

When Gunther is ready to finish his turn and resume level flight, he needs to use the ailerons roll the plane back to a wings-level flight attitude. He should begin to roll out several degrees ahead of the desired heading, because the aircraft will continue to turn until the wings are leveled. For steeper turns, more degrees before the desired heading should be allowed. As Gunther rolls the wings back to level, this again requires rudder in the direction of the roll in order to overcome adverse yaw and coordinate the transition. Also, the back pressure should be smoothly decreased as the plane rolls back to wings level. Some forward pressure may even be required to prevent the nose from coming up. In addition, Gunther can close throttle to the previous cruise setting in order to maintain airspeed. If the plane is trimmed for level flight, no stick pressure will be required once the aircraft has settled into the wings-level attitude.

Let's summarize the horizontal turn procedure:

1. Initiate the turn with your ailerons.
2. At the same time, coordinate the turn by applying rudder in the direction of the turn: "step on the ball."
3. At the same time, anticipate the tendency to lose altitude by smoothly applying an increasing back-pressure in the turn until the desired bank angle is reached; this increases angle of attack to produce more lift.
4. To maintain airspeed with the increased angle of attack, add power by opening the throttle.
5. As the desired bank angle is being reached, release the rudder pressure and aileron deflection. In *IL-2* some aileron deflection may be required to hold the bank angle.
6. Maintain back pressure on the stick throughout the turn.

7. Several degrees before the desired heading, use the ailerons to roll the wings back level, use the rudder in the direction of the roll to coordinate the turn, and decrease back pressure or apply forward pressure as necessary to keep the nose at the required attitude.
8. Return the throttle to the previous power setting to maintain airspeed.

4.6.2 The vertical

A horizontal turn is a common maneuver that the pilot uses to reorient the aircraft onto a new heading. They are normally done smoothly, but in combat are often performed hard and fast. Purely vertical turns are by comparison always performed quickly, due to gravity. Use a vertical turn to go up and before long you'll run out of airspeed. Use a vertical turn to go down and it won't be very until you run out of air. There's nothing leisurely about it, it needs to be performed quickly. Even if you don't run out of airspeed or air, an inefficient vertical turn wastes precious energy.

This is not to say that the pilot should use as much pressure as possible, because this can cause a stall or an undue loss of energy. Just keep in mind that timing and energy are important in a vertical turn. Before you engage in the maneuver, you have to know just where you want it to take you and whether conditions are right to initiate it. You have to have enough airspeed to reach your goal, or enough altitude to avoid the ground.

Some purely vertical turns are standard maneuvers that should be learned practiced, and are sometimes useful in combat. These include the loop, split-S and wing over.

4.7 Landing

Outside of combat, landing your aircraft is quite probably the most challenging and exciting procedure you are called to perform. Well, doing it properly is, anyway. There's nothing more beautiful than a good landing. On the other hand, few things are more embarrassing (or painful, if you survive the wreck) than racking up some kills in a sortie and then botching a landing in front of your mates. With some knowledge and training it's not hard to avoid this, and in time you might even become rather interested in performing good landings. While it is true that any landing you walk away from is a good one, and any landing where they can re-use the aircraft is a great one, you're not going to keep getting assigned fighter duty if fighter command learns that every time you go up they can kiss that expensive fighter good-bye. So get yourself revived with some radiator vodka, and let's talk technique. Making a safe landing, especially under non-ideal circumstances, requires a lot of concentration.

First, an overview of the landing procedure. Here are the major components of every landing:

- approach, in which you establish a glide slope toward an aim point on (or before) the runway
- correction, or getting your approach lined up with the runway and keeping it there
- transition from glide to touchdown attitude, called the flare
- touchdown and ground roll, or roll-out

Every single landing that doesn't involve crashing involves all of these components. Obtaining landing permission is also usually involved, at least that's what my CO tells me. The hardest of these stages to learn is setting up the approach.

As usual, you can use Denker's work to supplement the material here. The material in chapter 12 of his online book has been used in the preparation of parts of this discussion.

4.7.1 Approach

After you have found the airstrip and have it in sight, preparing the approach starts with setting your airspeed and altitude. Knowing what these should be requires knowledge of your aircraft, the runway altitude and weather conditions. Since it would be too confusing to try to cover all situations at once, we will assume you have good weather conditions and a runway at sea level on flat terrain, so you won't have to compensate for wind or do any subtraction to calculate your above-ground-level altitude (AGL). Typically you will need to descend from altitude before landing. During your descent to the airfield, slow the aircraft. A good altitude to begin an approach is at least $1000'$ (1000 feet, just over 300 m). Anywhere between 300–600 m is good, depending on your distance to the airfield. Prepare the approach by descending to within 300–600 m of the runway altitude and having the runway in sight.

The approach described so far assumes that the airspace around the airfield is clear, so that the pilot can determine his own approach. If there is any doubt whether the airspace is clear, the airfield traffic pattern will be in

effect. The airfield will typically have restrictions on altitude and airspeed in its airspace. See section 4.8 for more information on airfield traffic patterns.

Your aircraft has a rated speed below which it is safe to drop the gear, and another speed below which you can start extending flaps. (A few aircraft of course have fixed gear and/or no flaps.) Now that you are beginning your approach, you want to reduce your airspeed to below the maximum speed for dropping gear. If you don't know for a given aircraft, you can assume a value in the range of 250–300 kph. You cannot begin your approach while you are going faster than this. You can of course go slower than the gear extension limit. The airfield may have rules for altitude and airspeed of aircraft in the traffic pattern, so make sure you don't make anybody down there mad, they do have flak guns! There is also always a chosen side of the airstrip for approach, because the runway is no place to play chicken. Normally the approach side is the side into the wind, and the runway was built with local wind patterns in mind for this purpose. Unless you happen to know in advance, observe the local traffic pattern and approach from the same side.

After establishing flight at a good airspeed and altitude, maintain them and position yourself on the approach side of the strip. Your heading is not important unless you are in a traffic pattern, meaning you need not necessarily be on a specific heading relative to the runway heading. As you maneuver keep a sharp eye out for traffic, especially traffic below you if you are in a low-winged plane.

The next thing to do is to contact ground traffic control. They will let you know whether you are cleared for landing. If you are not equipped with a radio, it's broken or the controllers seem to be on coffee break, then you just have to keep your eyes out for local traffic, and especially on short final and whether the runway is clear.

Once you are at the right altitude and airspeed and have permission and are visually clear to land, you are ready to begin your approach. There are several different kinds of approaches, but for now we are only going to concern ourselves with a straight-in approach. Later you may want to experiment with curved approaches, which help in aircraft with poor forward visibility. In any approach, you are going to establish a glide slope, which is a steady descent at a given angle, and maintain it until just before it would smack you into the ground. You are going to aim the glide slope so that it brings you to a given point at or just before the beginning of the airstrip. This point is unimaginatively but appropriately called the aim point. The difficult part of all of this—and perhaps of any landing procedure at all—is learning to visualize the glide slope and judging where you are relative to the intended glide slope. We are only going to discuss it qualitatively.

The glide slope in a straight-on approach needs to be stable, meaning that once you are in it you ought to stay in it as much as possible in order to maintain a steady descent. A steady rate of descent on the glide slope will be achieved, but don't rely on your variometer to establish the glide, it reacts too slowly.[11] To help keep the descent steady, you want to lower the gear and extend flaps before you start the glide slope, while you are still a good ways from the field. Check again to make sure that you are below maximum gear extension speed, and drop the gear. Make sure that they are down by whatever means you have, such as lights on the panel or physical indicators. If they seem to be stuck try swinging the aircraft around a bit. You will probably need to throttle up slightly to compensate for the added drag, but unless you are already near stall speed (you shouldn't be), don't worry about slowing down a little. Next, verify that you are below max flap extension speed and start lowering your flaps in stages.

The best flap configuration for almost all aircraft is—can you guess?—landing flaps. As you extend the flaps, you can use forward pressure on the stick to counter the tendency to pitch up until the aircraft stabilizes. This helps prevent sudden changes in altitude and airspeed. Extending the flaps reconfigures the wing incidence and therefore angle of attack, allowing more of a nose-down attitude for the given airspeed. Allow the aircraft to stabilize and repeat the process for the second and third notches of flaps, at which point you will be have landing flaps. Now you need to retrim. The nose-down pitch is going to come in handy for visibility on the approach. With flap extension you are also going to lose some more speed and should throttle up as necessary. You are now ready to bring the airplane to its approach airspeed.

For each aircraft there is an airspeed at which, with gear and flaps in the landing configuration, it will stall in level flight. This airspeed is called V_{so}

V_{so} is the stall speed in landing configuration.

[11]None of the warbird flight manuals I have seen recommend using this instrument in the approach.

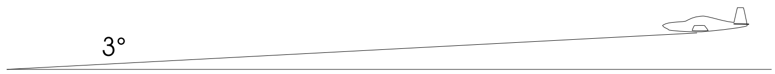


Figure 4.4: The glide slope should place the aim point just above your nose, and the field should not look too long or too flat.

and is very useful to know for landing. If you don't know what it is, you can determine it for yourself as long as you have some altitude for recovery after the stall: drop the gear and extend the flaps to landing configuration, and while keeping a close eye on airspeed, *maintain level flight* and adjust the throttle and attitude (using trim helps) until a wing starts to drop.[12] The airspeed at which this happens in level flight is V_{so}, and for most aircraft in *IL-2* is between 120–140 kph. Keep in mind that fuel and payload raise this airspeed! (Not that you should be landing with ordnance.) If you are returning to base with damaged wings, it is a good idea to test your new V_{so} stall speed at altitude before attempting a landing, in order to prevent dropping a wing on approach or during the flare.

Coming in too high or too fast is going to land you in a lot of trouble.

Approach speed is $1.3 \times V_{so}$.

Begin your approach after extending gear and flaps, by allowing the airspeed to drop to a value of about $1.3 \times V_{so}$. This is your desired airspeed for the approach. Learn these two values of V_{so} and $1.3 \times V_{so}$ for your aircraft. If for your aircraft V_{so} is 140 kph, then in your glide slope you should maintain right about 180 kph; this is a typical value for many aircraft. Lighter aircraft generally have lower values. As you lower the gear and flaps you should more or less maintain altitude but allow your airspeed to drop to approach speed. Now you are on the glide slope.

The glide slope itself is simply a steady descent at this airspeed. Technically, a perfect approach has a glide angle of 3°, which is not very steep and a flatter approach than most new pilots are comfortable with. The good news is that you can use a bit more angle and get away with it. A workable glide slope should place the aim point just above the nose of your aircraft (in single-engined aircraft). You can judge the steepness by how the field looks—it should not appear too long or too squat. If it seems long and thin then you are too high in the approach, and if it looks too squat and wide you are too low. Figure 4.7.1 makes some comparisons to demonstrate how the field should and should not appear. Since this is learned visually, it is best to watch a track to get the feel for it. (You can find some examples at Eastern Skies.) You want to descend at a constant rate, although there is of course room for making adjustments. If you descend too steeply, you

[12] Real aircraft will typically drop the nose in a straight-on stall, but in *IL-2* they drop a wing.

(a) Too high (b) Too low

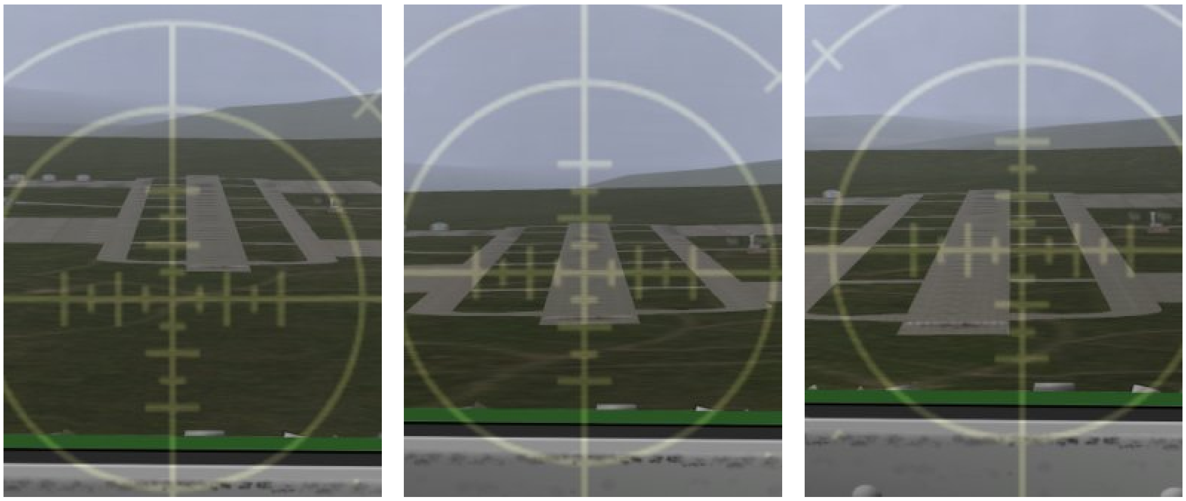
Figure 4.5: These figures illustrate approaches that are too high or too low on the glideslope.

are going to find it difficult to stay slow, and your transition between glide and touchdown will be much more critical. If you adopt a descent that is too shallow, you are going to have to add a lot of power and have a high attitude to maintain rate of descent and airspeed, making visibility very difficult.

You are now on approach. Hang on to that $1.3 \times V_{so}$, and stay on a glide slope that will bring you to the aim point before transitioning into a flare. We'll get to the flare, but what happens if you mess up before then? Let's have a look at how to correct any problems in the approach.

4.7.2 Correction

The glide slope is no place for day-dreaming. During your descent you will need to be aware of how you are doing in relation to your intended glide slope, and how well you are lined up with the runway. Even without wind, which we are not discussing here, you will probably need to do some



(a) too far left (b) centered (c) too far right

Figure 4.6: These three approaches show how to judge left-right alignment on approach.

correcting, especially if you have done a sloppy job of lining up the approach and initiating the glide slope.

The easiest and least critical correction to make is alignment with the runway. Correct large course errors with shallow, coordinated turns, and correct small ones with rudder only. Use the rudder to point the nose and use the ailerons to hold the wings level. Figure 4.7.2 shows three approaches: one too far to the left, one lined up on the center, and one too far to the right. Use the edges of the runway to help judge where the aircraft is lined up. Looking at the vertical line of the gunsight reticle provides a line to help us. In all three approaches, the aircraft is lined up with the runway heading. In 4.7.2 (a), the pilot is on a line that runs along the left-hand edge of the runway. This is seen because a point on the left edge at the rear of the runway lies directly above a point on the left edge at the front of the runway. So even though he is on the runway heading, if he continues his course he will be landing half off the runway. In (b), the pilot is on a line through the center of the runway, and will land right in the middle of the runway. In (c), the rear of the right-hand side of the runway lies directly over the front of the right-hand side, so the pilot is having the same trouble as the pilot approaching in (a).

The right way to make the correction is not to just aim for the middle of the runway. This would bring the airplane to the right point, but the aircraft would not be traveling aligned with the runway when it arrives. How then? On approach it is not desirable to make turns to correct. Instead, the pilot should slip the aircraft in the desired direction. This is done by dipping the wing on the side you wish to with the ailerons, and applying opposite rudder to keep the nose aligned with the runway heading, so that the aircraft is not turning. In (a) the pilot should give right aileron and a matched amount of left rudder. The aircraft will then slip to the right without turning. This should be done with sufficient airspeed, because the slip also increases drag on the aircraft. The motion must also be coordinated, because of the danger of a snap roll.

If you see that you have gotten too far off too late in the approach to correct, simply go around (see section 4.7.4) instead of flailing about. And if you land on an a ridiculously short runway that is at least a kilometer wide, then you needed to correct about 90°.

The more difficult corrections are those to the glide slope. They're especially difficult because without knowing your distance from the airfield, it's difficult to know what your altitude should be. It simply takes practice to learn to judge the glide slope correctly. The main thing while practicing is to think about maintaining a steady glide slope with the aim point staying steady in your view, and making small changes to correct. Think about whether you are too low or too high based on Figure 4.7.1. Practice making approaches at various angles of steepness, and notice how much or how little power is required to maintain the glide at the approach speed.

Above all, be careful with your airspeed—this will help you survive long enough to get the necessary experience to land. Many pilots have a tendency to want to use their stick as the up/down control, and their throttle to control speed, as discussed in section 3.6. As you know if you read section 4.3.2 on the power curve, at low airspeed and low altitude, that kind of thinking is extremely dangerous. You simply don't have enough airspeed to perform a zoom climb of much duration at all, and you also don't have enough altitude to recover from a stall. In the approach you can use your throttle to regulate rate of descent and the stick to help control airspeed: the flippers *primarily* control airspeed. However, you need to use both controls together smartly, and especially watch to make sure your airspeed and rate of descent stay in the right range. See section 7.2 of Denker, which has already been partially covered, for some more advice on changing airspeed.

If you find yourself below the glideslope, add power in increments and use the stick to maintain airspeed. Anticipate finding the glideslope again and restore power settings in a way that will prevent overshooting or dramatic control manipulation. In other words, make smooth transitions. If you find yourself too high, throttle back and use small amounts of stick pressure to maintain airspeed. The slip technique used for left-right correction can also be used for wind correction and can also be used to burn off excess altitude when well above the glideslope.

It bears repeating—maintaining airspeed is critical. Too fast is better than too slow, although if you are really too fast you should go around. If you are too slow, use some forward stick and open the throttle to get back up to speed, then readjust the controls to maintain speed.

4.7.3 Flare and touchdown

The concept of the flare is simple and beautiful. You're familiar with the glide slope, and the goal of landing is to be on the ground and *no longer flying*. No longer flying means essentially that the wings are producing less lift than the weight of the aircraft, so once you have touched down the wings should be in a stalled condition. The flare is what transitions the aircraft from $1.3 \times V_{so}$ to less than V_{so}. It does this by using the excess $0.3 \times V_{so}$ to reduce the descent so that the aircraft is levels out flying at stall speed just above the runway surface. The nose of the aircraft smoothly goes from the nose-down approach to the nose-high touchdown attitude, increasing AoA. The extra lift brakes the descent and burns off the excess speed, and the aircraft settles gently onto the ground. All the pilot has to do is close the throttle and pull the stick back gently back with the right timing. And timing is what the flare is all about.

As you can gather, timing the flare has to be done to achieve these three things at the same time: the aircraft reaches stall speed (V_{so}), is flying level, and is at or just barely above the ground. To do this, you should start to execute the flare about two seconds before the aircraft would carry you into the aim point. How high off the ground you are depends on your airspeed and the steepness of descent, but is typically very low, only about 6 m off the ground. Developing a sense of timing for the flare is not so very hard for pilots who have learned how to establish the glide slope and hold their aim point. A good idea is to watch some tracks where it is performed and think about the situation, then practice it.

The danger of mistiming the flare is very real and very high. Flare too soon and you will be close to stall speed too high up. Flare too late and you will hit too hard. It is possible to adjust the flare as you are performing it, but this leads to problems and should be avoided.

How quickly you bring up the nose is important to get a feel for. If you pull back too hard you will zoom back up and be too high and too slow. How far you bring the nose up plays a role too, because this can also lead to a zoom or an early stall. However, the tendency is rather to not bring the nose up too far, because pilots tend to want to see ahead and as a result don't bring the nose up high enough. You should not be able to see the runway ahead of you during the latter stage of the flare when the aircraft is in landing attitude, so use the edge of the runway for alignment and watch objects at the airfield and the horizon to judge whether you are too high.

Since it is difficult and not always practical—especially if you are dealing with wind or combat damage—to get the flare just right in one fluid motion, it is a fine idea to perform the flare in two parts. In the first part, called the roundout, reduce your descent to level flight without giving away all of your excess airspeed, so that you are a meter or two higher than during a fluid, one-part flare. In the second part, called skimming, maintain level flight and *gradually* raise the nose, allowing the airspeed to bleed off and the aircraft to settle onto the ground. This two-part flare technique uses more runway but is a safer approach.

4.7.4 Abort!

As has been mentioned, if you are too low, too high or too far to either side, and too close to touchdown to smoothly correct, you should break off the approach. Do this by raising the gear and smoothly adding power to transition to level flight. If you have sufficient altitude and airspeed, begin raising flaps and climb back out to traffic altitude, around 300–600 m AGL. If the surrounding terrain is high, extend along the runway heading and climb as required. Once you break off the approach, level out and begin to climb away from the airfield, you are "going around." The go-around procedure is described in section 4.8.

4.7.5 The roll-out

Once the aircraft is on the ground, your job is to keep it on the runway, slow it down to taxiing speeds, then get it off the runway. The first two of these are called the roll-out, because you are just letting the aircraft roll safely along until most of its speed dies off. As simple as this sounds, there are a few things you have to be aware of.

One thing that occasionally surprises pilots is that being on the ground does not mean being safe. In some ways, a fast-rolling aircraft on the ground is in more danger than one flying just above the ground due to the contact of the wheels with the ground. The rolling aircraft can pivot about the wheels along all three axes of movement. It can yaw, roll and nose over, but no longer due solely to the wings. This is why a smooth, safe roll-out requires attention on the part of the pilot.

The greatest dangers in taildraggers are ground loops. Tricycle-gear aircraft are less prone but not immune to ground loops. Although ground looping is a danger during taxi and take-off, it is a greater danger during the roll-out. The center of gravity (CoG) is located behind the landing gear, and while the aircraft is accelerating forward or at constant speed, it has little reason to try to pivot around the gear. By contrast, on the roll-out the aircraft is slowing down and any turning motion that brings the CoG out of line of motion with the gear causes the CoG to want to pivot around the gear to be in front. This ground looping can be partial, or the aircraft can swap ends rather hurriedly. Once the pivoting motion begins to happen, the aircraft has a turning momentum and the sideways pivoting motion is hard to stop. The best method is to realize that the tendency to ground loop, which is present as long as the aircraft is moving since the adverse torque is also always present, must be constantly be countered with the rudder. As the aircraft slows down, the more rudder will be required, because the lower airspeed will cause rudder authority to reduce.

The second greatest danger is nosing over. Upon touching down after the flare, the aircraft might still have enough lift to get off the ground again, and it might not. Either way, there is still enough lift on the flippers to pivot the aircraft about the wheels. For this reason, it's a very bad idea to push forward on the stick during the roll-out. Keep the nose high—the aircraft will slow down faster in this attitude. The more common cause of nose-overs is riding the brakes too hard. This is typical of pilots who see a danger ahead, such as the end of the runway or a parked object, or who simply want to turn off onto *this* taxiway. The result is that the CoG rotates not around the gear to the side, but over top of them. The propeller strikes the ground, killing the engine violently, the airframe is damaged, and the pilot gets a rather queasy feeling in the stomach.

These are the reasons that it is advisable to to land hot. Slow down to the appropriate airspeed on approach: the flare will burn off most of your excess, and you'll be able to avoid overly long roll-outs.

The only safe way to get the aircraft to slow down after landing is through drag and brakes. Brakes can be pulsed—applied, released and reapplied—in order to help slow the aircraft and avoid nosing over. The best way to maximize drag is to keep the flaps down and keep the nose high: the wings and flaps create maximal form drag in this position. This is not obvious to all pilots flying aircraft equipped with tricycle gear. Leaving the flaps down will increase drag, but also increases lift. You should raise flaps at least one notch if you are worried about being too fast after touch-down, as this will reduce lift and help keep you on the ground, even if you don't slow down as quickly. Another way to increase drag is to open the radiator. Of course, you should always check to make sure that you have closed the throttle all the way. Killing the engine will slow the aircraft more quickly on the ground, but this is to be reserved for emergencies, since the aircraft may called on to maneuver quickly and may not be able to do so with the engine off.

When the aircraft is at taxi speeds, it is safe to leave the runway. Watch out for other aircraft, and especially watch your six. Many online pilots, and certainly AI pilots, have not "read the instructions" and don't know how to taxi safely!

4.7.6 Summary

Since this section on landing has so much material, some might find it handy to have a summary of the steps to take for landing:

1. Reduce airspeed to about $\sim$300 kph and descend to 300–600 m AGL, with the runway in sight.
2. Position your aircraft so that you can approach the runway, and keep the runway in sight.
3. Below $\sim$300 kph, lower gear and throttle up to compensate for drag. Adjust radiator to keep engine within operating limits at the lower airspeed.
4. Below max flap speed, $\sim$250 kph, lower flaps in stages, maintaining airspeed and altitude with forward pressure on the stick and opening the throttle further to counter drag.
5. At the appropriate distance from the runway, select an aim point and begin a glide toward it. Adjust throttle and pitch to maintain a steady descent of $1.3 \times V_{so}$, typically 180 kph.
6. Flare the aircraft and gently close the throttle all the way allowing the aircraft to settle in a nose-high attitude onto the runway at V_{so}.
7. Use rudder to keep the aircraft from ground looping, and allow the aircraft to roll to taxiing speed.

8. Taxi off the runway to the assigned parking area.

Now you're well equipped to get back in one piece from your training sessions. There's no substitute for practice, so make an effort to end every mission, small or large, with a successful landing. Get up there, and "try not to prang the bloody thing!"

4.8 Airfield operations

Airfields are a center of air traffic. To avoid collisions, it is important that each pilot understand the rules that will enable them to be aware of where other aircraft are. This also helps in the coordination of landing approaches and emergency procedures. Learn the traffic pattern, communicate with the tower if one is available, and you will greatly decrease the chances of a tragic collision. Don't be the one who makes it home, only to throw it all away.

Airfield airspace typically extends only about 2–3 km from the airfield, and at least 1000 m above ground level (AGL). It is thus considered safe to fly without regard to traffic in the airfield pattern when well above 1000 m AGL or more than 2 km from the airfield. It is, of course, still important to keep an eye out for incoming and outgoing aircraft.

The two main categories of airfield operation are take-off and landing. Because take-off can be coordinated while aircraft are on the ground instead of in the air, the rules for take-off procedures are simpler and less restrictive. Under normal conditions the airfield airspace will be empty during take-off, especially at the beginning of a mission. If the airspace is not clear, departing aircraft should take off straight out and climb. Once they are clear of the airfield airspace, they can then turn to their desired heading. If the airspace is clear, the aircraft may turn once they have established a climb. This may be desirable for aircraft that circle in order to form up before following mission waypoints.

It is important to note that when the airfield is busy, all aircraft should take off using the same heading, in order to avoid runway collisions. Furthermore, this very important rule governing right-of-way applies in every situation:

> Landing aircraft always have priority over aircraft that are taking off. Aircraft waiting to take off must keep the runway clear until aircraft on approach have landed and exited the runway.

Landing operations involve the use of a traffic pattern, which is to be respected immediately upon entering the airfield airspace. The traffic pattern includes the following: an assigned use of only one approach heading, so that all aircraft fly and land in the same direction; either a rectangular or circular pattern relative to the runway in use; and assigned altitude and airspeed. Assigned altitude is usually between 300–600 m AGL. If a pilot approaching the airfield airspace specifically knows that it is clear, he may enter the airspace and establish a landing approach as desired. However, if there is any doubt, he must enter the airfield traffic pattern as follows.

- If possible, fly over the airfield above 1000 m AGL and observe traffic.
- If there is no risk of enemy aircraft in the area, switch on navigation lights.
- Descend to the assigned traffic pattern altitude before entering the airfield airspace. This is necessary because of restricted downward visibility.
- Reduce airspeed to the assigned pattern airspeed. If this is unknown, assume an airspeed between 220–270 kph.
- Check the airspace carefully for airfield traffic, and maintain a generous distance.
- Enter the airspace on a heading approximately 180° opposite that of the runway heading in use.

It is important to note that it is not permitted to pass other aircraft in the traffic pattern. Aircraft that are damaged and require an emergency landing have priority. It is critical to give such aircraft right-of-way.

The following sections describe the two landing patterns in general use.

4.8.1 Rectangular pattern

The rectangular pattern is quite useful because its four legs allow the pilot to maintain good awareness of his orientation to the airfield, and is easy to fly. It has the disadvantage of being somewhat congested for airfields with a large amount of traffic. It is not used by AI traffic, but may be quite helpful

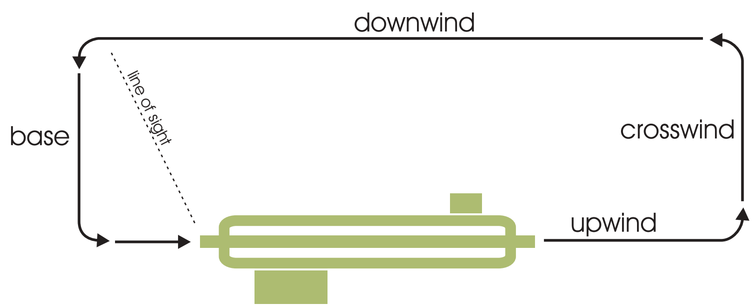


Figure 4.7: The rectangular traffic pattern has four legs.

for use by human pilots in the absence of AI traffic. It is standard to use a left-hand traffic pattern, as illustrated in figure 4.8.1.

In a left-hand rectangular pattern, the following four legs are flown: crosswind, downwind, base and final. The final leg is the leg on which approach for landing is made. The crosswind and base legs may be of varying length, so long as the airstrip is visible. They should be the same length, and must be sufficiently long to allow preparations in the base leg for final. The upwind leg is the same as the final leg, and is so called after a go-around, or to differentiate it from the approach section of the final leg. The upwind leg may be shortened considerably if desired.

The pattern is entered at the assigned airspeed and altitude on the downwind leg, parallel to the runway. (An airspeed of 220–270 kph and altitude of 300–600 m AGL should be maintained if unassigned.) Here the preparatory landing checklist should be followed and the aircraft prepared for landing. The $90°$ left-hand turn to the base leg is made when the runway threshold appears to be about $45°$ behind the left wing (between the 7 and 8 o'clock positions). On the base leg, ask for permission to land if the airfield is equipped with ground control. (All airfields in *IL-2* happen to have ground control. If ground control is not in use, proceed with landing as long as the approach and runway are unobstructed.) If permission to land is not granted, maintain altitude and airspeed and go around, continuing to follow the pattern, keeping an eye out for any aircraft going around below you. If permission is granted, turn on the landing light, extend gear and flaps, keeping stable flight, maintaining sufficient altitude for the approach. Begin the turn onto final for approach early enough to come out lined up with the runway. Stabilize the glide slope as described in section 4.7. Complete checklists and land.

If on the landing for any reason you need to abort the approach (see sec-

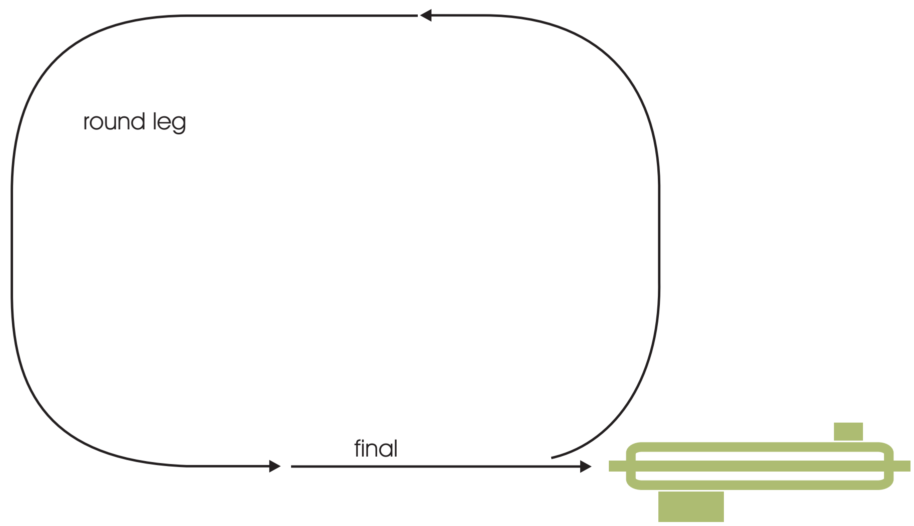


Figure 4.8: The circular traffic pattern

tion 4.7.4), go around as follows. Abort the approach by adding power and raising gear, gain airspeed and altitude and retract flaps, and resume pattern altitude. It is permissible to turn onto the crosswind leg before pattern altitude is achieved. Resume the pattern by turning onto the downwind leg. Make sure to go through checklists and get permission again before landing.

4.8.2 Circular pattern

The circular traffic pattern is the pattern used by AI traffic, and therefore is the default traffic pattern used in *IL-2* missions. It has the advantage of being able to handle large amounts of traffic, but the disadvantage of pilot disorientation concerning location relative to the airfield.

The circular pattern consists of a straight final leg and a long, round leg. An example pattern is provided in figure 4.8.2. The round leg is not a perfect circle, but rather an extended loop on the approach side of the runway in which the aircraft is in a continuous turn. Alternatively, this leg can consist of straight and curved segments, or even a triangular or box-like pattern if desired. The principle difference to the rectangular pattern is that this pattern is maintained on one side of the airfield, and not flown parallel to the runway. It is also standard practice to fly the pattern to the left of the approach.

These patterns as flown by the AI often extend beyond visible range of the airfield, especially in low-visibility conditions. This is not a desirable feature and should be avoided if possible. The Curtiss P-40 pilot training manual specifies the following: "You have been used to flying a rectangular pattern. Now, with few exceptions, you have to fly a circular pattern, varying at different fields but generally to the left . . . . Circle around the boundaries of the field, staying close enough to the field and keeping enough altitude to make an emergency landing from any position." However, when AI-controlled aircraft are present, it is safer to use the AI pattern. This can be done by following AI aircraft at some safe distance, then increasing distance to the AI by slowing down before the runway. This distance should be large enough to allow the AI to land or be sufficiently down the runway while you are on final approach. If the pattern is particularly difficult to follow or visibility conditions low, the pilot may have to decide to land with a partially obstructed runway or select a modified flight pattern that permits keeping the runway threshold in sight.

The round leg of the pattern should bring you to the final leg with sufficient distance to the runway threshold to set up an approach. Begin landing checklists and request landing permission before or just after entering the final leg, depending on its length. If permission is denied, go around by maintaining altitude and airspeed, and recommence following the round leg once near or past the runway threshold. Be careful to keep an eye out for any aircraft going around from below. If permission is granted, turn on the landing light, extend gear and flaps, and establish the approach at an appropriate distance to the runway threshold. Complete checklists and land.

If for any reason you need to abort the approach (see section 4.7.4), go around as described in the previous section, following the round leg as you climb back to pattern altitude. Make sure to go through checklists and get permission again before landing.

4.9 Take her for a spin

Actually, don't! Spins are a good way to forego your pension. There is yet another aviation proverb—part of an endless supply, probably—that 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 [8]." Spins occur when the aircraft is placed in a stalled condition that results[13] in a straight-down descent in which the aircraft rotates rapidly about a vertical axis. The path of the aircraft is shaped very much like a spiral staircase, and is also referred to as "augering in," named after the carpenter's tool for boring holes with a spiral groove. This mode of flight unfortunately develops into a very stable state, so that if the pilot does not take proper action in time, the spin results in a fatal crash. The stall/spin accident has been the result of many fatalities.

What causes a spin? When the wings are at a high angle of attack, near or in a stalled condition, roll damping nearly disappears, meaning that any movement in the roll axis causes the aircraft to roll without control input.[14] At even higher angles of attack, any rolling motion will even accelerate, corresponding to dropping a wing. If then an aircraft in the stalled condition is for any reason subjected to a yawing motion, a difference in angle of attack of the two wings is created that causes the wing at a higher AoA to drop a wing. The nose will also drop, and the aircraft enters a flight regime in which the nose is low and one wing is more deeply stalled than the other. Due to the insufficient lift of the wings, the aircraft descends rapidly. The less stalled (or possibly unstalled) wing will cause the aircraft to rotate in the direction of the deeply stalled wing at a high speed. At this stage the spin is likely to be very steep, with a significant nose-down attitude. This is the initial stage of the spin, also called the incipient spin. The first rotation of the spin represents an important stage, as it is easiest to recover the spin in this stage. As the aircraft continues to rotate, the centrifugal force of the spin counters the undamped rolling tendency, and the spin begins to

[13] The *IL-2* flight model has been criticized, with justification, in regards to stalls and spin entry. As mentioned in the section on stalls on page 45, in *IL-2* it is practically impossible to experience a straight-on stall; there is always a tendency for one wing to drop, as if one wing always stalls before the other. Flying an aircraft into a stalled condition is not sufficient to spin an aircraft—spin entry also requires a yawing motion. While in *IL-2* the spins are fairly well modeled, it appears that a stalled condition tends to lead to a spin without requiring a yawing motion to initiate it, so that there is a tendency to spin more than in real life. This is discussed along with the stall model in this thread in the Ubi forums.

Even with these problems, the spin entry and behavior in *IL-2*, along with spin recovery, provide a decent approximation of the flight envelope of WWII aircraft. The problem is not that the makers do not understand flight dynamics, but rather due to necessary comprises in the choice of modeling. The mechanics of the situation and governing mathematics become much more involved. Spins are also very complex, and it could be suggested that tampering with the flight model could result in simulated flight behavior even less desirable.

[14] In this high angle of attack, aileron input creates little lift and lots of drag. The effect of the ailerons can reverse in this condition, so that the wings roll in the opposite direction of normal aileron input.

stabilize. After a few turns, the centrifugal forces flatten the wings, further developing the spin and making it more stable. The tendency is for the spin to become less steep. Typically a flat spin develops, in which the nose is at a fairly shallow attitude and the radius of the turn is extremely small. This is a dangerous stage that in many aircraft may be unrecoverable. The rotation of the aircraft may increase to some 3–5 seconds per 360° rotation. [8]

Obviously, it is to the pilot's advantage to know how to prevent a spin and be able to recover from spins. Both of these tasks involve principles common to all aircraft, but procedures are aircraft dependent, so the pilot must learn his aircraft. Spins are commonly entered during hard turns or quick changes in direction at low speeds, such as at the top of a climb. The pilot's intention in such situations is commonly to quickly change direction and maneuver to a position of advantage. During the maneuver, the pilot pushes the aircraft beyond its performance capability, driving the wings into a high angle of attack and inducing a stalled condition that immediately develops into a spin. Even if a full spin does not develop, much time is lost, along with energy (in the form of altitude and airspeed) and positional advantage. Furthermore, after having recovered from the spin, the pilot will be for at least some time slightly disoriented and will probably have to reacquire his target. The pilot has therefore frustrated his own intention. The ability of a pilot to know an aircraft and place it at or near maximum performance while avoiding the stall/spin situation is an important part of what is known as "pushing the edge of the envelope."

Some pilots consider the ability to purposely enter a spin to be an advantage in combat, used for the purpose of evasion in a tight spot—a spinning aircraft makes a difficult target. As long as the pilot is able to control the spin and has sufficient altitude to recover, this must be considered a valid tactic. However, it is very defensive in nature and seems suitable only as a desperate measure. A spin maneuver is coupled with loss of altitude, airspeed and situational awareness.

4.9.1 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 practically impossible to spin. Others require a fair amount of care to prevent the spin. The P-39 with its mid-engine placement is a notorious example. Significantly troublesome in *IL-2* is that no yaw is required to spin the aircraft, so stalls quite often lead to spins. However, no spin can occur without the wings stalling, so the key to preventing a spin is to prevent a stall. From section 4.1 we already know how to do prevent a stall: *avoid excessively high angles 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.

Since stalls occur at high angles of attack (beyond the critical angle of attack), they can occur at any airspeed. This is why the pilot maneuvering for position in a high-speed turn may drive the wings into a stalled condition and induce a spin. Stalls that occur due to excessive back pressure are called *accelerated stalls*. Unfortunately, there is no gauge the pilot can use to directly measure the angle of attack. However, if he knows that the wings are at a high AoA, he can listen for the buffeting sound that precedes a stall and anticipate it. If a force feedback joystick is used, the stick vibration accompanying the stall may also serve as a warning. To prevent the stall, it is usually sufficient to quickly *reduce the angle of attack* by relaxing back pressure on the stick. If the wings do stall, there is still a chance to counter the wing drop that begins the spin by quickly applying opposite rudder. However, this requires an experienced eye and very quick reaction time on behalf of the pilot.

4.9.2 Recovering spins

The general thing to do to get out of a spin is to oppose the direction of spin and to unstall the wings. 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 a slightly different spin characteristic, so it is best to get to know the behavior of each aircraft. Furthermore, the spin behavior is likely to change with fuel and ammunition load.

In most aircraft, the technique for recovering *non-inverted spins* is as follows:

- Center the stick by releasing it. Do *not* pull back or give aileron input; this only makes things worse.
- Cut throttle all the way back to idle.
- Note the direction of spin, then give full rudder in the opposite direction of spin. This reduces or stops the rotational motion. Continue holding opposite rudder until rotation stops.

- If *after applying the above control procedures* rotation persists, push the stick gradually forward, being careful to maintain neutral aileron input. Pushing the nose down helps unstall the wings.
- Once the rotational motion has stopped, finish unstalling the wings by keeping the nose in a downward attitude.
- After recovering from the stall, smoothly apply full throttle and recover from the dive normally, maintaining sufficient airspeed for stable flight.

It should be noted that not all aircraft may be successful with this procedure. For example, the real-life recovery procedure of the P-39 is a notable exception. However, in *IL-2* even the P-39 can be recovered in the above fashion, it just takes a bit longer to come out of the spin. One notable exception are certain models of the Bf-109. For example, it can be extremely difficult to recover a well-developed spin in a Bf-109 F-4. In *some cases,* extending gear and even flaps can aid in getting the nose down and exiting the spin.

One aspect of spins that has been mentioned but is very useful to note is that they are much easier to recover in the early stages. The best chance of recovering from a spin therefore comes from a quick and correct course of action immediately up realization that a spin may occur or is occurring. It is important to immediately *release the stick* so that it returns to the neutral position. This should be the first reaction because gives the wings a chance to unstall before the spin occurs or further develops. Reducing the *throttle to idle* helps to let the nose drop, and is thus also a good early reaction. If this is insufficient to arrest the spin or unstall the wings, you should immediately continue the recovery procedure. However, it is essential to first *note the direction* of the spin before applying rudder to oppose the spin, because if the rudder is applied in the wrong direction it is likely to accelerate spin development. So remember,

> React quickly after the stall or early in the spin to recover the spin before it develops. Neutralize the stick and chop the throttle. If the spin occurs or continues to develop regardless, first note the direction of the spin before applying opposite rudder.

If you spin the aircraft while inverted, it is possible that an inverted spin will develop. This normally occurs only in acrobatic maneuvers such as at the top of loops. Normal spin recovery procedures tend to make an inverted spin even worse. Inverted spin recovery involves opposing the spin rotation with opposite rudder as in a non-inverted spin, and *increasing* back pressure on the stick until rotation stops. Then speed must be allowed to increase sufficiently and the aircraft can be rolled level. Inverted spins have a dangerous tendency to disorient the pilot, so great caution is recommended.

If you spin at altitudes too low for bailing out, you have no choice but to try to recover the spin. If you spin at higher altitudes, try to recover the spin until you approach dangerously low altitudes. If the recovery procedure fails, leave yourself enough altitude to exit stage right: see section 5.8. However, this is not a failsafe method! The high centrifugal force of the spin may prevent you from being able to bail. Therefore, if you find yourself going past the first spin rotation in an aircraft that is difficult to recover, consider bailing immediately, before the centrifugal forces increase.

CHAPTER 5

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]

[1]The words are literally: "Enemy fighters, left higher!" English-speaking pilots might say, "Enemy fighters, 10 o'clock high!"

Of course you had 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 kilometers 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.

5.1 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 combat pilot, gunnery is very probably the first skill that you ought to develop after basic 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.

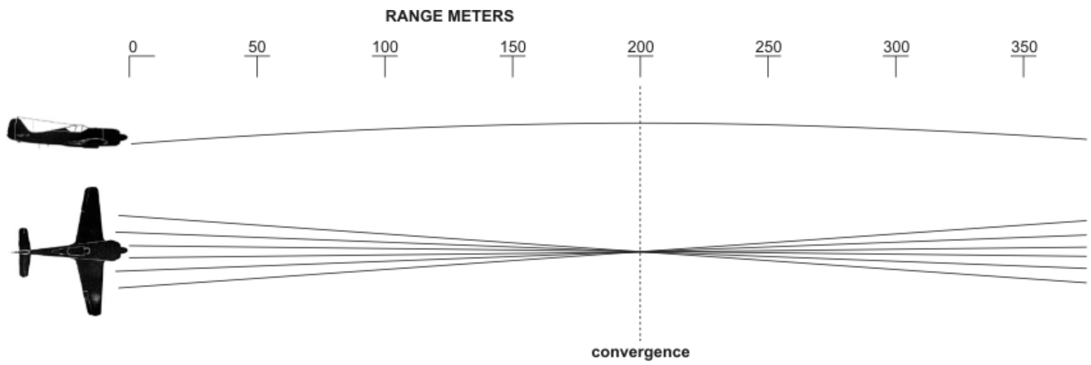


Figure 5.1: The paths of the projectiles are converging towards each other horizontally from the wings or to a certain height from below the pilot's line of sight. In either case this doesn't happen until a certain distance from the plane, which can be adjusted.

5.1.1 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, which is a curved path: they go away from you very quickly, but they also fall towards earth. The implication is that it can be difficult to visualize where your rounds will pass in the vertical plane relative to your target. This is a fundamental problem of vertical convergence.

What's more, most or at least many of the aircraft you will fly 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. This is a problem of horizontal convergence.

The answer to these worrying problems is to set the paths of the bullets to converge at a given distance in front of the plane that you expect the target to be. This is illustrated in figure 5.1.1.

5.1.2 Gunsight reticle

The gun sight in most planes in *IL-2 Sturmovik* uses a reflector sight, or reticle, which is the primary means of estimating where your shells will go,

[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.

as the crosshair 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 crosshair. These are meant to be used to help line up deflection shots, which you can read about below.

Shifting the gunsight

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`.

5.1.3 Armament: machine guns and cannons

Armament can make or break the effectiveness of a fighter design. Any fighter aircraft that is not equipped to take down its opponent will be ineffective, and the ability to quickly take down an opponent—ideally in one pass or given a certain window of firing time—can mean the difference between victory and defeat. Important factors influencing armament are size (caliber) and mass (weight) of the projectiles, their velocity (usually measured at the muzzle), the rate at which they are fired and the scatter of the rounds. Further factors are whether the rounds are explosive, and whether they are a tracer round.

The caliber and mass of a round are tied together, since the mass of a round tends to increase with caliber.[4] The velocity of the round when fired, together with its mass, determines its kinetic energy it has according to $E_k = \frac{1}{2}mv^2$.[5] The higher the kinetic energy, the more destructive the round

[4]The relation is not one-to-one, since it is possible for two rounds of identical caliber to have different masses.

[5]Note that the velocity of the round is far more significant than the mass, since it is squared. However, the more massive a round is, the more difficult it is for the gun to provide a higher velocity, that is, more energy is required from the explosive charge in the gun. This in turn has an impact on the rate at which rounds can be fired, because of the amount of mass of moving parts required of the gun for handling the high power of the discharged round. Much research went into improving materials and methods to improve the efficiency of guns in this regard during the war, but limits are nevertheless imposed.

will be when it impacts its target. Explosive rounds explode upon contact with the target, greatly increasing the damage done.

Velocity also has a significant impact on the projectile trajectory (ballistic). Faster rounds have a flatter curve, as pictured in the top part of figure 5.1.1, which facilitates aiming. The projectile ballistics of tracer rounds also differ from that of normal rounds, since they are lighter and the phosphorescent material that burns from friction with the air to make the round visible also reduces drag, thus affecting the trajectory. Since in guns that use tracers only about one out of every six rounds is a tracer round, the result is that the majority of rounds are following a different flight path than the tracer rounds. It is difficult to tell whether this is modeled in *IL-2* however, and it does seem that tracers can effectively be used to track the shot.

The rate of fire of a gun affects the rate at which the destructive energy of the projectiles can be applied to and concentrated on the target. A higher rate of fire results in more rounds landing within a given area, or indeed hitting the target. However, a higher rate of fire may also involve a gun design that produces more scatter in the projectile trajectory. Scatter may be of benefit for hitting the target, but also reduces the concentration of rounds that strike a given area of the target. The destructive power of a gun is a combination of the destructive power of each round (mass, velocity and explosiveness if applicable) and the rate at which the rounds can be delivered to the target (rate of fire and scatter). A .303-caliber or a 7.62 mm light machine gun can deliver a tremendous number of rounds in a short amount of time, and still do considerably less damage than say a 20 mm cannon delivering high-velocity rounds at a lower rate of fire. A far fewer number of 20 mm rounds arrive at the target in a given time window, but the destructive energy of each round more than compensates. This larger-caliber, high-velocity design is especially useful in some aircraft, since they can take out their target even if just provided with a snapshot.

An example that goes to the far extreme is found in the 37 mm T9 cannon of the P-39. This cannon has a rate of fire of a mere 3 rounds per second (and only 30 rounds), and each projectile has a low velocity, which makes aiming with this cannon very difficult. However, each round is so destructive that a single round is often sufficient to bring down even a light bomber. In addition, every other round contains an explosive charge.

Machine guns are thus often effective for finding targets or distracting enemy pilots (both human and AI), and while they can do some damage, it is cannon fire that is usually going to bring armored planes down. Machine-gun rounds are lighter and are fired much faster in comparison to cannon rounds, and due to their smaller size and weight, lots more of them are usually loaded.

5.1.4 Angle-off and deflection 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. Of course, if you'd like to hit the target right where your gunsight pipper is pointing, then the target had better be at a distance where your shells will all converge. The reason it is easy to hit the target from these two positions is obvious: there is little or no difference in the direction of flight of the two aircraft. There is little difference in the velocity vectors (not only speed but also direction) of the two aircraft. Angle-off shooting refers to shooting in this situation, since the angle is very low and therefore "off." The relative ease of shooting from this position is why most pilots try to maneuver their aircraft onto the six-o'clock position of their target, despite the danger of overshooting (with the aircraft, not the bullets).

Deflection shooting refers to all of the other cases, when the direction of your flight and that of your target have an angle between them. This can be restated to say that there *is* an appreciable difference in the velocity vectors of the attacking and target aircraft. This is usually the case, and since bullets require some small time to travel to the target, the attacker must compensate for the angle by pointing his guns ahead of the target, so that after the guns are fired, the target and bullets both merge at the same time and place. This is referred to as leading the target. The amount of lead required in the deflection shot depends not only on the angle between the velocity vectors of the aircraft (this includes both the relative speeds and directions of the aircraft), but also on the velocity of the fired rounds, the distance between the aircraft, the position of the projectile trajectory relative to gravity, and the rate at which the aircraft are changing their direction if in a turn. In short, deflection shooting is hard stuff. No wonder so few of the fired rounds reach the target! This is also the motivation behind producing armaments with very high rates of fire, to increase the chances of hitting the target.

Getting good at deflection shooting requires a lot of practice. You have to learn to develop a feel for the thing. It helps to use a consistent convergence distance and learn to judge the distance of enemy aircraft. The rings of gunsights are useful for helping to determine the distance of an enemy target: if you know the width of the target and can see how wide it is relative to the rings, you can estimate the distance of the target. But to learn to compensate for the factors mentioned above simply requires practice. It will help to set up a lot of missions offline using the QMB (section 9.8 on page 145), and to watch tracks made by other pilots.

When making deflection shots, generally give more angle than you think is necessary. Usually, inexperienced pilots should give two to three times the lead they think they need. Anytime you are shooting, don't clench the stick. Instead, hold it gently and squeeze only the trigger. Rudder pedals might help a lot here since you won't have to twist the stick if you need rudder input.

There is a set of wonderful articles [12] written by Andy Bush that will help you learn a lot more about gunnery.

5.2 Situational awareness

The absolutely most valuable thing to a pilot[6] is an understanding of his surroundings and its dangers, including the condition of his own aircraft. This is true both in and out of combat; a skilled pilot is constantly gathering information about his situation.

> *I was flying over the Coral Sea with Honda and Yonekawa as my wingmen. After some fifteen minutes of patrolling we noticed a lone Airacobra flying about 3,000 feet over our fighters, cruising slowly. The pilot seemed oblivious to everything; he maintained his course as we approached from behind and below. . . . Incredibly, the P-39 allowed me to close in. He had not the slightest idea that I was coming up on him. I kept narrowing the distance until I was less than twenty yards beneath the enemy fighter. He still had no idea I was there! The opportunity was too good to waste: I snapped several pictures with my Leica. . . . The amazing formation flight of my Zero and the P-39 continued. . . I climbed slowly until I was off to the right and slightly behind the enemy plane. I could see the pilot clearly and I still could not understand his stupidity in not searching the sky around him. He was a big man, wearing a white cap. I studied him for several seconds, then dropped below his fighter.*
>
> *I aimed carefully before firing, then jabbed lightly for a moment on the cannon trigger. There was a cough and (I discovered later)*

[6]beyond a bullet-proof aircraft

> *two shells from each weapon burst out. I saw two quick explosions along the bottom of the P-39's right wing, and two others in the center of the fuselage. The P-39 broke in two! The two fuselage halves tumbled crazily as they fell, then disintegrated into smaller pieces. The pilot did not bail out.*
>
> —*Saburo Sakai [13]*

Not surprisingly, there are good ways of increasing awareness, 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[7] 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

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

- 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 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. [14, 15, 16]

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.

5.3 Detection and closing

The OODA process teaches us that you have to be able to make observations and orient yourself faster than the enemy. You also want to detect the enemy and maneuver to a position of advantage 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. This requires a constant scanning of the sky, working with a knowledge of the enemies habits and preferences. Closing involves maneuvering your aircraft to a position of advantage, nearly always above and often, if possible, behind the enemy.

Simple as that may seem, there is a lot involved in this competition to spot the enemy first, and as much or more in maneuvering to an advantage. Detection has a lot to do with the viewing systems discussed in the next section.

5.4 Viewing systems

There is rarely a better way to raise and maintain situational awareness (SA) than to have a look around. The viewing system determines to a large extent how well you can do that. The goal of this section is twofold: to provide you with a nearly comprehensive overview of all available viewing systems and their options at once, to describe the pros and cons of the systems and raise some issues that are commonly debated, and to give some tips on how the aids might best gainfully employed to keep your situational awareness high. A few important SA aids that are not actual visual aids are grouped in this section together with the visual aids; they are considered as a part of the viewing systems and sometimes described as visual aids.

The viewing systems and SA aids can be divided into two categories in *IL-2*: those that are commonly available and those that can be set in the difficulty settings. Some of the common aids that are not available as options in the difficulty settings can however be disabled. The common visual aids are: panning with the mouse (mouse look), panning with a joystick hat switch or key commands, snap view with a joystick hat switch or key commands, width of view, toggle gunsight, in-flight map, speed bar, heads-up display (HUD) and subtitles. The visual aids that can be disabled through difficulty settings, let's call them "difficulty-setting visual aids," are: icons (both friendly and enemy), aircraft and ground-object padlock, turning the cockpit on or off, external views and map icons. These are all described in the following sections and summarized in Table 5.4.

5.4.1 Common visual aids

Most of the visual aids that are commonly available stem from the a real pilot's ability to move his head and eyes. Others allow you to gather information that is typically available in the cockpit without having to fight the viewing system to actually study the cockpit, and also to receive important information from the simulator. Many of these aids can also be disabled to suit your taste.

Pan and snap views

It would be a pretty hard life as a combat pilot if you could only ever just look straight ahead. A real pilot is able to move his head to the side and forward in addition to swiveling it about on his neck, although this is greatly hindered and highly stressful during high-G maneuvers. His eyes have a very high resolution, over 500 pixels per inch compared to a monitor's 96 dpi [17]. He has binocular vision—the offset of his two eyes allows him to see somewhat around nearer objects while fixing vision on objects further away. His ability to turn his torso about in the cockpit is usually restricted by a double-strap safety belt that keeps him in his seat during G-maneuvers, but he did have the option to take the time to remove this and squirm about.

View system	Control	Description
Mouse look	Mouse movement	Pan view with the mouse
Pan view	Hat switch or key commands	Pan between fixed viewpoints
Snap view	Hat switch or key commands	Snap between fixed viewpoints
Width of view	`Page Down`, `End`, `Delete`	Wide, normal and gunsight view widths
Toggle gunsight	`Shift+F1`	Toggle centered and gunsight view
In-flight map	`M`	In-flight “kneeboard” map
Speed bar	Toggle, user-defined	Displays airspeed, altitude and heading
HUD	Setting in `conf.ini`	Aircraft- and simulation-relevant messages
Subtitles	Setting in `conf.ini`	Translation of radio transmissions
Icons	Toggle icon types, user-defined	Colored text beside aircraft and ground targets; provides distance and identity
Padlock	`F4`, `Shift+F4`, `F5`, `Shift+F5`, `U`, `Y`	Point-of-view follows selected target
Cockpit on/off	`F1`, `Ctrl+F1`	Switches between virtual cockpit and no-cockpit views
External views	`F1`, `F2`, `Shift+F2`, `Ctrl+F2`, `F3`, `F8`, `Shift+F8`, `Ctrl+F8`	External pan and chase views for all aircraft
Map icons	`M` toggles in-flight map	Displays map icons for all aircraft and ground-objects

Table 5.1: View systems

In comparison to real-life visibility, the ability to change the pilot point of view (POV) is fairly limited in *IL-2*. You can swivel the POV around a single point, you can lean closer to the gunsight, and, unlike a real pilot, you can change the width of your view. In some conditions turbulence on the airframe or G-forces will shake or move your POV in a realistic way, and probably in a way that's not very convenient. That's about it. Well, *IL-2* isn't real life; the view systems are adaptable to help compensate for that, and agreeing on how to compensate is what difficulty settings are all about. First let's look at how to change the POV "manually."

In order to change the POV you can use pan mode or snap mode. You can switch between these two modes at any time in flight by pressing `F9`. There are two possibilities for panning, one with the mouse and one with the joystick hat switch or key commands. The mouse view is the smoothest and allows for the manual adjustment of any POV within the limits of the panning range. Its major disadvantage is that usually both hands are usually needed for flying; it is difficult to use the mouse while piloting. To overcome this difficulty, some use one hand on the joystick and one on the mouse, moving the mouse to the far side of the joystick for faster access. Others use a track-ball mouse that can be manipulated with a thumb, leaving the rest of the hand free. Still others use special hands-free viewing hardware—TrackIR is by far the most popular. See section 10.7 for more information. Although the mouse or mouse-emulation solution may be complicated, the view itself isn't: you move the view freely about. The view will remain at the POV where it was last told to look until a new input is given.

The other option is to pan between fixed viewpoints. You can use the joystick hat switch to move one fixed POV to the right, left, up or down. The POVs are located every 45°. Starting from the straight-on POV, press once to the right and once up and you will be looking 45° to the right and 45° up. You can alternatively push the hat switch once to the position between right and up, which is the equivalent of pushing once to the right and once up. (This takes some skill to master.) If you don't have a joystick hat switch, you can achieve the same results with key strokes. Look in the `Controls` submenu from the main menu or on the Quick Reference card to learn the key strokes.

The pan mode allows you to move to a POV and leave the view there. It also allows you to move the view up and down. Sometimes when you are panning you will need to immediately regain the straight-on POV, without having to think about what mouse movement, button sequence or key strokes are necessary to get you there. To this end there is a command assignment available in `Controls` under the section `PAN VIEW` called `Center`

View. The default key assignment is NumPad 5. You might consider assigning a joystick button to this command, as it is very practical in pan mode. It can also be used with TrackIR to help recenter the view. You might also want to assign the same joystick button to Look Forward in the SNAP VIEW section; it is possible to assign the same key or button to both due to the mutual exclusivity of the two modes.

Snap mode switches to a new POV only so long as you hold the button or key for that position, and returns the view straight ahead when the button or key is released. The default snap views assignments allow you to snap to POVs in the horizontal (relative to the aircraft of course). If you want to be able to snap to POVS that look up or down, then you need to assign them yourself. This can be practical if your joystick supports shift functions, so that many or all snap views can be assigned. Again, the same result can be achieved with key assignments.

Toggle gunsight

In order to look through the gunsight reticle, pilots often had to lean their head .

In-flight map

Speed bar

Heads-up display

Subtitles

5.4.2 Difficulty-setting visual aids

The visual aids that can be disabled through difficulty settings, or "difficulty-setting visual aids" are: icons (both friendly and enemy), aircraft and ground-object padlock, turning the cockpit on or off, external views and map icons

icons (mp_dotrange)

Padlock

know that if you padlock an aircraft with icons off, you get a green triangle around it. If you toggle the icon types you can turn the triangle off and just have the padlock function. I think if icons are on you get a red or blue triangle (or color corresponding to team color).

I like the padlock and I don't like the padlock. I used to use it a lot before I got TrackIR, now I try to always only use the TIR, even if padlock would be easier. What's good about padlock is that it helps negate an advantage TIR users would have in online combat. There are at least two things I don't like about padlock. One is that it allows a sort-of radar function to see planes you otherwise wouldn't see when map icons and icons are off. It's very hard to not use this, and it makes you very lazy about scanning the sky with your own eyes. The other thing is the way that the view bobs about when the padlocked target gets behind, below or above you. It makes it hard to keep an idea of your flight attitude. I can deal with not having a view of my nose, but the back and forth is often too much.

Another issue is that when icons are off it simply locks on to the next aircraft, friend or foe. However, this is a question of laziness. I feel padlock should be used to track a bandit you are pursuing or evading. You should not use it until you are close enough to id the bogey as a bandit (or friendly) and are engaged. However, when you are close enough to engage, the aircraft are close together and it picks up the wrong target, that's annoying and inhibitive.

5.5 Engine management

Our discussion of engine management will be limited to those aspects related to combat. Success and failure in combat hang on aircraft performance. In turn, aircraft performance depends on at least the following factors: pilot performance; airframe design, configuration and condition; weight; and engine performance. Pilot performance and engine performance are probably the two most critical factors, and this section deals primarily with the latter. Combat places many special requirements on aircraft control, and is where engine management becomes the most critical and dynamic.

Engine management is not overly complicated in *IL-2*. The propeller, mixture, turbo- and/or supercharger, and other systems are all greatly simplified or not controllable by the pilot. This leaves principally the throttle control, radiator and war-emergency-power (WEP) system available for engine management. These systems are discussed in the following sections, followed by a discussion of possible application tactics in combat.

5.5.1 Throttle

Incorporate material from the CEM guide on throttle and power here.

5.5.2 WEP

An engine is normally designed to run at a certain nominal level of operation for prolonged periods of time without damage. Aircraft engines are typically able to run like this at full rpm and throttle. In fighter aircraft, many engines "make metal" if run too hard (bits of metal start showing up in the oil), and their expected life is measured in hours of operation, with a typical value being around 100 hours. However, combat pilots have a knack for getting themselves into a pinch, and of course they need a trick to help them get out of it. Engine designers obligingly develop ways for pilots to get extra power out of their engine, but at the cost of engine wear. Most WEP systems work by increasing the pressure inside the engine, also increasing stress and operational temperature. The amount of time that the WEP system can be engaged without damaging the engine permanently is dependent on design, and thus different for each aircraft. It also depends on the engine temperatures before engaging WEP. Typical WEP engagement times are on the order of only a few minutes. Pilots are strictly warned that this extra power can only be had for short periods of time, and since it can do serious engine damage, it is considered to be emergency power. Many pilot accounts indicate that they use it rarely. After all, you have a crew chief to account to.

It is a simple matter to engage the emergency power, simply use the `W` key or assign it to a button in the Controls menu.

Since engaging the WEP system for too long costs you in terms of engine degradation, it is best to use it only when it will give you maximum gain in return. You will get the best gain from WEP when you are slow, because it provides better acceleration at low speeds than it does at high speeds. Most WEP types provide you with extra power for only a relatively short time before crippling or frying your engine, so you get the most benefit when you need to accelerate back to a good maneuvering speed or to climb quickly. It is therefore best saved for those tight moments when the extra power will save your neck, which might be boosting turn performance at a critical point, catching someone at the end of a vertical climb, and so on. With experience you will learn to judge when you need power most. Again, running WEP can be the main cause of overheating your engine, in which case it will run worse than if you had never engaged WEP.

WEP brings a small increase in top speed (perhaps around 10 kph IAS), which can be useful when you are desperate to catch someone or leave them behind, but again since it quickly overheats the engine this is of minimal benefit. Long chase scenes are more often won by whoever can keep their engine running at maximal long-term performance.

In the end you have to decide how you will distinguish between real aircraft practice and what performance you can get in the game. Some pilots will disregard historical tactics and try to use WEP and radiators to ride the edge of engine damage. They may have it down to a science, and that is of course a valid approach. The engines in *IL-2* are not fully modeled, and you can get away with a lot that you can't with real engines. For instance, you can use WEP fairly recklessly during a period after engine warm-up and normal operational range. A lot of pilots use it during take-off and the beginning stage of their climb to altitude. The only side-effect appears to be that the engine gets warm faster.

5.5.3 Radiator

Aircraft engines are cooled either with air, or air and liquid engine coolant. Air-cooled engines work by allowing air intake to flow over the engine and out through cowling or radiator flaps. Liquid-cooled engines cool the engine by circulating engine coolant liquid through the engine, and then cooling the liquid in the radiator with air flow. In both cases, the rate at which air flows over the engine or radiator determines how quickly the engine can be cooled. The rate of air flow is controlled by flaps on the cowling (cowl flaps) or near the radiator (radiator flaps). Opening these flaps permits more air flow, but at the cost of drag on the aircraft, which slows it. If the engine is not sufficiently cooled, it will of course tend to overheat.

In real aircraft, cowl or radiator flaps can normally be set at any position between two extremes by the operation of a lever in the cockpit. In *IL-2* aircraft, this system is simplified to two settings: closed, meaning minimal airflow, and open/automatic, meaning fully open or open to the extent determined necessary. Therefore, the pilot is essentially presented with a simple choice: open and cool faster at the cost of drag, or closed and let the engine temperature rise or, at best, cool slowly.

5.5.4 Propeller system

The propeller systems represented in *IL-2* are greatly simplified. Most of the aircraft historically used by the *VVS* use constant-speed propellers, and the

Luftwaffe machines used variable-speed, constant-speed or aeromechanical props. With the exception of variable-speed props, which control the propeller blade angle directly, these systems automatically control the propeller blade angle in order to achieve a desired rpm. The desired rpm is selected by the propeller control. In *IL-2*, the propeller control is automatically linked to the throttle control. This automatic linkage works by adjusting the prop control proportionally to the throttle, from idle through the WEP range. Thus, changes in the throttle setting are accompanied by a corresponding change in engine rpm.

The propeller control may be de-linked for such purposes as cruise. A value of `Prop. Pitch0` (see the Controls menu) corresponds to the smallest blade angle, which will unload the engine and result in higher rpm. A value of `Prop. Pitch9` corresponds to the largest blade angle, which loads the engine and results in lower rpm. However, for maximum performance it is best left on automatic, or `Prop. PitchAuto` under Controls, meaning the prop control is linked to throttle. This leads to the main conclusion out of this discussion: the pilot is relieved of operating the propeller system as a separate control during combat.

As the aircraft speeds up the propeller windmills, which means that the increased rush of air over the propeller causes it to speed up, so that the rpm increases. When this happens, the rpm governor automatically adjusts propeller pitch (blade angle) to maintain rpm. At high speeds, it runs into a limit in the range of prop pitch and can no longer limit rpm, so that the rpm may increase above the selected value. If the selected rpm is close to the maximum allowed rpm (this is usually the case at full power), the result is overspeeding of the engine. Although this effect can destroy engines, it appears to have no effect on the engines in *IL-2* except to accelerate temperature increase.

5.5.5 Application in combat

A large portion of combat-related engine management revolves around the management of engine temperatures.

Mostly what is required is the highest power settings in order to maintain an energy advantage (speed and altitude). The highest non-emergency power setting is of course 100% throttle. You can also use WEP judiciously, as previously described. The art of engine management in combat is keeping your engine in a condition to give you high power at the critical moments when you really need it. Let the other fellow burn up his engine instead!

More to come in this section.

5.6 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 9.6), 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 Eastern Skies on the Maps page.

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 10.3.2) 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. The speed bar can be be assigned a key (see section 9.2.1) 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.

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.

5.7 Radio commands

5.8 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?

5.8.1 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 salvageable, 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.

5.8.2 Forced landings

5.9 Combat training

So much to read, so much to learn, so much to do! But how do I actually *get started* practicing and training?! This section offers some hints for the new combat pilot about how to get started, especially with gunnery and maneuvering.

The first step is actually to get properly patched up to the final version of *IL-2*, as described in section 9.14. There's nothing worse than learning an aircraft and its handling and gunnery, only to discover later with a patch that something has changed and you have to relearn it. With the patches you will of course get many bug fixes, but also new aircraft and features. It can be argued that some patches made certain aspects worse; for example it might be argued that patch version 1.04 has the most accurate aerodynamics. However, the final version is overall the best version, and the version anyone you meet online will be flying.

Once you have learned how to control the aircraft using the basics in the chapter on flight, gunnery is truly the next step. This is because gunnery requires learning to maneuver, hold the aircraft steady, and learn to judge the shot. The best way to train gunnery is to progress in small steps. The Quick Mission Builder (see page 145) is an invaluable tool for this job.

Choose any old aircraft with guns to fly and take your first step by setting one or more friendly bombers or transports in your flight, and set their `Skill` setting to `Rookie` so that they won't fire back or maneuver as much under fire. Nice-sized aircraft such as the Pe-8, Me-323, Ju-52 and He-111 will do nicely. Don't select any enemy aircraft. Before starting, go to the difficulty section and click on `Realistic`. Then deselect `Limited Ammo`, so that you'll be able to shoot as long as you want, and also select any of the visual aids that you might desire, depending on how good you are at spotting enemy aircraft. Icons, map icons and padlock can come in handy when you are just starting out. Experiment with leaving cockpit and externals on or off. Again, it is recommended to leave all of the settings affecting physics, such as `Stalls & Spins`, `Torque & Gyro Effects`, etc. on, in order to get a feel for the physics of flight, which after all is where the most fun is. Click `Back`, choose any map, weather, altitude and other changes you'd like to try out, then `Fly`. Try to find the friendly bombers, and then shoot them down! Ignore all pleas over the radio to stop shooting at friendlies. Have fun tearing up these virtual aircraft.

Start out by lining yourself up directly behind them. Learn to match their speed, altitude and heading and fly behind them varying from 0.05 to 1.0 kilometers (icons will come in handy here). Practice firing from these distances while matching their flight. Aim for different parts of the aircraft—the wings, then engine nacelles, the tail section and the wing roots—and note how gravity and convergence have an effect depending on distance from the aircraft. Restart the mission to get more bombers if need be, and keep at it.

Next try firing at them from angles—from below, below and to one side, a slashing attack from above, then a slashing attack at some angle, from dead astern (from the side), from head on and so on—and note just how much deflection is needed. Remember from section 5.1.4 just how complicated deflection shooting is! Work hard at being able to hit these large, slow targets from all angles, and then work on focusing on specific parts of the aircraft. This may seem like tedious work, but the training will pay off because you are learning a most fundamental skill that many pilots overlook.

Once you have done this, select a different aircraft and repeat the process. This is important! Only in this way will you learn to compare the effect of different armaments, and why they are so important. Can you take a Pe-8 out the same way with a Yak-1 as with a Bf-109, P-39, IL-2 or with a FW-190? Doing this will also help you learn which aircraft have what armament.

Now that you have mastered hitting large, slow targets, give yourself a bit of a challenge: make it an enemy rookie bomber, so that it fires back. Now you will have to learn how to line up a shot while evading enemy fire, and you will immediately learn the value of setting up slashing attacks and being able to hit the bomber from odd angles.

After you have become adept at this, increase the `Skill` setting of the AI aircraft. They will get better at evading and shooting back—too much in fact for your comfort. Also try using smaller bombers, such as the Pe-2 and even the Ju-87. Your confidence has grown, but can you hit the smaller targets? You may get the feeling that all of this training could take many hours and days of effort. Well, it is a training program, isn't it?

Once you can hit enemy bombers of various sizes consistently and satisfactorily from various approaches, remove some of your aids. First take away limited ammo, and find out how much some of the various aircraft have to spend. This is important, since unlimited ammo is a difficulty setting that is unpopular (online), highly unrealistic and, ultimately, un-fun. Next, take away some of the visual aids. See how well you can get along without them. Force yourself to become adept at doing without them. You will find that if you are able to do well both with and without them, you will become a much better and well-rounded combat pilot. Now you're a bomber buster.

Congratulations, you are ready for the real test: fighters! These make difficult targets because they are smaller, faster and nimbler. Use the same approach in the QMB, selecting friendly fighters at the rookie setting and using unlimited ammo at first. Practice shooting them down from directly behind and all the other various angles. Next try varying this simple theme by flying a different aircraft, and then shooting at some different fighters. Once you feel you are getting good and are up for the next challenge, try this out: use the radio to command the friendlies to cover you. To do this, use the keys `Tab`, `2` and `1`, which works if the friendlies are in your flight. If they are in another flight, use the keys `Tab`, `6` and `1`, which commands the whole *Escadrilia* (3–5 *zvenos*, or flights). This command causes all of the friendly aircraft to fly behind you, which will offer you the opportunity to shoot them down while they are trying to maneuver on you, but without them trying to shoot you down. Keep varying things. Increase the AI `Skill` setting, and take away the visual aids and unlimited ammo difficulty setting.

Finally, set up a scenario with a single enemy fighter on a low AI setting. You should have learned some useful maneuvers and gunnery skills by now, so you should be up to it! Try a few different fighters to fly in and against. If you feel confident, fight two enemies, then try it with a wingman. Even after lots and lots of practice, that first experience when the enemy is trying to shoot you down is a rush! Enjoy it. As you become more competent in shooting down AI enemies, keep in mind that they are nothing like human enemies. Although the AI in large use more realistic tactics than online human players, the element of human unpredictability brings a challenge and enjoyment like no other. Come on out and fly with us.

Practicing ground attack works in quite a similar way to practicing gunnery skills: use the QMB. You can set targets in the `Target` pull-down menu, or set up large targets such as ships or large formations of ground vehicles using the FMB (section 9.12). Practice different attacks as described in chapter 7. You can also hop in the rear seat and work on learning to shoot down enemy fighters. Work up the scale gradually. Try out flying online, you'll undoubtedly find that ground attack with and against human opponents can be more exciting by far than offline.

CHAPTER 6

Fighter combat maneuvers and tactics

6.1 Turns

6.1.1 Turn performance

Parameters affecting performance

6.1.2 Types of turns

Types of turns (corner, sustained, nose position, lead, lag, etc.)

6.2 Pursuit

Pursuit (although classified by Shaw as BFMs)

6.2.1 Pure

6.2.2 Lead

6.2.3 Lag

6.3 Basic flight maneuvers (BFM)

6.3.1 High and low yo-yos

6.3.2 Nose-to-nose and nose-to-tail turns

6.3.3 Vertical and oblique turns

6.3.4 Rolling scissors

6.4 Angle and energy tactics

6.5 Section tactics

6.5.1 Comms and brevity

6.5.2 Wing doctrines

6.5.3 Tips

CHAPTER 7

Ground pounding

Ground attack, or ground pounding, 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.

7.1 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.

7.2 Delivering the payload

7.2.1 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.

7.2.2 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.

7.2.3 Rocket attack

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 ever-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.

7.2.4 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.

7.2.5 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 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.

7.3 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.

[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.

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.

7.4 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:

Anti-Aircraft guns AA, also known as AAA (anti-aircraft artillery) or flak (German for *Flieger Abwehr Kanone*). Anti-aircraft guns, whether heavy or light flak can be destroyed easily with almost any weapon from machine-gun upwards: a short burst of fire is usually sufficient, especially if it is cannon. Of course, they have the unpleasant habit of firing back and are quite small and hard to hit. Techniques for surviving flak are dealt with later in this section. When you are staring down the barrel of flak in order to take it out, 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 in 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 or even machine-gun 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. When they are already on the ground, you need major structural damage or fire. 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. The real headaches start when you have to face tanks. Tanks are one of the most historically important ground targets in the eastern theater, and one of the toughest nuts to crack in *IL-2*.

Different armor strengths are accurately modeled for different makes of tank, but in practice it is difficult to distinguish between different kinds of tanks 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 attack 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; it is also 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 *IL-2*, 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 armor can be prevented from reaching the station you are defending by destroying the bridge. Use bombs or rockets to destroy bridges.

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

7.5 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. If you are flight leader, you can order your AI planes to attack your target, and follow them in once the flak has locked onto them, giving you a clearer run. This might get you court-martialed in a real war, but 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, steel-nerved and 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 may choose to fly over the target area to pick out your targets in advance—for instance, to distinguish armored from soft-skinned vehicles. You can then use your payload (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 a hard and hopefully 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 maneuvers.

Sequential attack is nevertheless 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 *IL-2* will sometime use this technique, so if you are following an AI flight leader watch out for your flight moving into a 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°, 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 or the target sufficiently annihilated. 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.

7.6 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!

CHAPTER 8

Flying online

Flying online is a rewarding experience because it exposes you to the ideas and skills of human wingmates and opponents. Most online pilots currently fly online using Forgotten Battles, and few are left who fly *IL-2*. This is a natural progression, but this guide is for *IL-2*. The methods used to connect for online gameplay are essentially identical, so there is no great loss by describing only *IL-2* in this guide.

If you would like to host a game and invite others or are invited to fly with a host, then the host must provide his IP address. The host and guests must then use the in-game Multiplay menu to set up the connection as described in section 9.11. Basically, the host must first set up the server, selecting the type of multiplay (dogfight or coop), select the mission and difficulty settings, and then load it. The clients (guests) may then enter the host IP address, and the mission details will be loaded by Internet and the client will be added to the game. There are better ways of connecting of course, and these will be briefly discussed in the next section, but this basic mechanism often comes in handy.

8.1 Finding online hosts

The more sophisticated and practical way of connecting to hosts is through an additional game lobby. The word lobby means a large entrance or reception room, and game lobbies are just that: an electronic waiting area where pilots can communicate and join up together. The lobbies allow pilots to meet up, see who else is doing what, communicate with each other and establish the host and allow others to join, all before *IL-2* is launched.

8.1.1 Ubi.com

IL-2 comes with a program that asks for permission to be installed when *IL-2* is installed. This program is a dedicated *IL-2* game lobby that allows hosts and clients to connect to each other for online gaming. Further documentation

8.1.2 HyperLobby

A useful and very popular method of arranging online sessions comes from the Czech Republic through the online game lobby named HyperLobby, written and maintained by Jiri Fojtasek. This program is free to download and use and is hosted at `http://hyperfighter.jinak.cz/`. Installation is simple and it is very user friendly and uses an intuitive method of establishing connections between host and participants. It is easy to host sessions and join servers, track others who are online using HyperLobby, and includes a pager system for exchanging messages. Several different rooms are available, some dedicated for use of online wars.

To use HyperLobby, you must download the most current version of the program and install it. Then close *IL-2* if open and launch the HyperLobby program. You will have to register a new account the first time you use it. You can now select the game (IL-2 Sturmovik) and login. This must be done either manually or automatically each time you connect to HyperLobby. Once in, you will see the main room with menus of dogfight and coop servers, together with the delay time from your machine to the server. These servers are clickable to find more information about the server, such as the players present and the difficulty settings. Try joining some servers, and enjoy! Further documentation is available at the main site.

8.2 Coop and dogfight servers

8.3 Difficulty settings

8.4 Online etiquette

So you've decided to go online and test your mettle against actual human pilots, but don't want to come off as either a complete "n00b" or break the "rules" of online play. This section is meant to provide some basics concerning what is expected behavior, and to outline a few conventions of courtesy.

Before we get to the finer points of saluting, let's get to the heart of online etiquette, the one rule that goes before all else:

> Don't be a Jerk.

If you can remember that, chances are the rest of this section is really just window-dressing. There are a few other things you should know to be further appreciated, and probably should know online. For lack of a better order, here are a few important ones in "alphabetical order."

Ask questions If you don't know what you're doing, ask! Lots of folks will be more than happy to answer you in a polite manner. Don't constantly apologize for not knowing what you're doing. If somebody asks a question that you know the answer to, answer it politely, and don't be smug.

Cheating There are two aspects to cheating that you must be aware of. The first is the `Cheating Detected` message that appears in the upper-right-hand corner of the screen. It has nothing to do with cheating at all, but everything to do with Internet connections. That message essentially indicates that there is a fair amount of lag going on. Lag is a time delay between the host server and the individual player machines connected to it. A certain number of people have found that they can alter their connection speed in order to intentionally induce lag and thus warp around a server. To fix this, an autokick feature was introduced to servers that works based on excessive lag and, rather unfortunately, uses the on-screen text `Cheating Detected` to indicate this condition. Few people really try to cheat this way, so please learn to interpret this message as the simple presence of lag.

Cheating Detected!

The second aspect is accusation. Never accuse anyone of cheating. If the pilot in question is an experienced player who who's really into flight sims, they'll probably take a screen shot and use it as proof of their skill—there is no higher compliment than being accused of cheating in a sim where the flight and damage models are closed. If the pilot is not so experienced or have an over-developed "serious gland," they're likely to become very upset and you'll have made an enemy rather than a friend. The flight-sim community is a close one, and you're likely to be seeing the same people for a very long time in a lot of other sims. Accuse a lot of people of cheating often and your reputation may follow you, probably resulting in you getting booted from servers for causing trouble.

Never assume that just because externals are on in a server that folks are using it as "radar" to detect you before seeing you–it's not only impolite to accuse people of doing so, it could very well be completely false. This appropriately leads into the next section.

Complaining This is a High Crime. The server settings are available for review before you enter a server; it is your responsibility to look at them. Likewise, you must read the briefing at the start of the mission and obey the server rules. Entering a "full real" server (one with all difficulty settings enabled) and berating the host for not enabling padlock or icons will gain you no sympathy and, if you persist, booted out of the server. What? You don't like "all planes" servers with icons, optional cockpit and no AA protection for the airfields? Very well, exit to find a new one—but don't forget to type something like "Salute! Thanks for hosting!" before doing so. (This will be your secret code phrase for "Arcade weenies!") You can ask for a change in settings on the server where you are; some hosts will do so if others chime in as well. But be polite.

If somebody's shooting you down a lot, don't gripe about it. Learn to avoid that player, as he's an ace of sorts! Or, better yet, start to play as part of a team (see below).

Cursing Don't curse in the chat buffer. It irritates everyone and really makes those with kids mad. A seven-year-old sitting behind his dad to watch while he plays online does not need to read the "F-word," thank you. Some regular dogfight-server hosts will give one warning and then boot for a second offense. Other hosts have a "no swearing" warning as part of the mission briefing, and will boot on the first offense.

Know your skill level If you can't tell a FW-190 from a P-39, perhaps a no-icon server isn't for you. These things come with time. If you're in a server where you're hopelessly lost or having so much difficulty that it's no fun, then give a "Salute!" and move on. There's no patented "right" way to play the game.

Matching plane sets Many dogfight servers are "all planes," meaning that just about every plane in the sim is available. Look to see who's flying what by pressing the S key once you've started out, in order to see what folks are flying. If fifteen of sixteen players are all in 1942 planes, perhaps you should rethink your selection of the ME-262 or LA-7. It's not "wrong" to pick a plane that's "superior" to the others, but you'll find that everyone will appreciate you being a good sport.

Play as part of a team Just because you find yourself in a dogfight server doesn't mean you can't show some team spirit! Fly along with others on your side, escort a bomber, call for help and let folks know where the bad guys are. Assist in kills, watch the other fellow's six, take out anti-air guns, and get in the game. You'll not only make everyone glad you're there, you'll have more fun. If others don't want to play as part of a team, ignore them and find others that do. In coop missions, team play will be essential to achieving the mission goals.

Salute! Typing `Salute!`, <S>, `S!` or the "russified" `C!` into the chat buffer indicates that you are saluting the other players. This is not only a greeting, but also a common response after shooting someone down or being shot down yourself. It means the battle was won fairly, that you respect the other player even though, for example, you just fooled them into diving after you and losing all of their control surfaces, or that you respect the fact that they fooled you into diving too fast! It can also mean, "No hard feelings, I'll get you the next time!" "Good gravy, man, I'm in a TB-3. It's not like I can maneuver out of the way of your head-on pass, try not to ram me next time," "Great battle, I really thought you'd get me (or, I'd never get you)."

Pilots commonly salute when entering or leaving a server. In short, the S! is a sign of respect to the host for putting up a server and to other pilots. Keep in mind that it is not required—you are not necessarily snubbing anybody if you don't use it, nor is anyone else who doesn't use it snubbing you. In addition, use of the S! is interpreted by some as gloating or smugness. It isn't. If it is, shrug it off.

Shooting bailed pilots While some think nothing bad of it, many players do, particularly in scripted servers or tournaments. The best course of action is to simply not shoot parachutes. It doesn't hurt or help you to do so. It adds insult to injury for most people. Doing this is can get you booted on some servers, and if you do it you take the risk of taking the fight beyond the virtual skies.

Skill Some players are very skillful. Others are not. Never tell someone they stink at flying! If they do, they probably know it. Only offer help once; nobody likes somebody critiquing them constantly in a game. If you stink at it, don't worry about it. There are no cash prizes for shooting planes down, just see improvement as an interesting challenge. Don't single out new or poor players. Go after the more skillful first, and allow the inexperienced pilot a chance to figure things out and learn that people fly differently than the AI. If you can, help the other player out in non-verbal ways, such as using maneuvers that they have a better chance of keeping up with and learning from. Only taunt players whom you know well—and be mild about it and clearly humorous. Remember that messages in the chat don't always convey your intended good humor.

Stealing kills If you see two pilots fighting and one has the upper hand (and is on your side), orbit around, take up a number-two slot behind him or maneuver in a perpendicular plane to establish a higher energy state, but *don't shoot.* Let the guy that has done all the work finish him off. You can always ask if he needs help; chances are he'll say yes and move off so you can get the shot. If you do shoot down a heavily damaged plane in a big furball, consider typing "Salute! Team!" or something similar, which is a very nice way of saying that it was you that put the last bullet in the plane, but not most of them. You might also follow up with an explanation, such as "That was XXX's kill, not mine. Great flying XXX!" You'll make friends and be appreciated for it.

Squadrons Those funny numbers and letters in front of everyone's names represent virtual squadrons. A squadron is essentially a club of sorts where guys get together at the same time and fly. Sometimes they practice with each other. Squadrons allow you to gain entry into tournaments, online wars, etc. They are often based on a historically unit or squadron, but not always. There are players that just stick something in front of their names to avoid looking like mercenaries. A mercenary is the term for independent flyers as they're often invited to join tournaments as part of a squadron without formally joining one.

If you see a coop forming that's all one squadron or has "XXX_Squad_Practice" in the title of a dogfight server, ask before taking a slot or when first joining it to find out whether you're welcome. If the server is private it will probably be password-protected, but not always. Chances are you will be welcome, but if they ask you to please not join, do so with a "Salute!" (In this case the salute will be your secret code for saying "Fine, you arrogant elitists, I'll go play elsewhere since you're not worthy of my skills.") They'll remember you were respectful and chances are invite you in next time. They might also invite you in to play the "spoiler" in their server as they practice. Be warned, though, they're almost sure to be on voice comms and are probably practicing team tactics—you will most likely be ganged up on. They may even invite you to join at some point, as most squads recruit based on personality rather than skill.

In conclusion, just be nice, be yourself, relax, and have fun. Be respectful of others, and they'll be respectful of you. And if all else fails, remember that you can host servers and missions yourself!

CHAPTER 9

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.

9.1 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*)

9.2 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.

9.2.1 Commands

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.

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 you create a new pilot he starts out with the set of default commands. This could come

[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.

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

9.2.2 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. . .

9.2.3 Joystick settings

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

9.3 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. (The official site now also includes information on the aircraft in *Forgotten Battles*.)

9.4 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.

9.5 Hardware setup

9.5.1 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 10.3 instead for a detailed description of what all of the options under `il2setup.exe` can do for you.

9.5.2 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.

9.5.3 Sound setup

9.5.4 Input

9.5.5 Network

9.6 Tracks

The ability to make tracks in *IL-2* is a great feature, allowing the game engine to play back missions exactly as they occurred.

9.6.1 Capturing tracks

9.6.2 Reviewing tracks

9.6.3 Sharing tracks

9.6.4 Track woes

The track recording system does not always deliver perfect results.

9.7 Training

This section allows you to use the track feature of *IL-2* to see flight demonstrations with accompanying text. This feature can be extremely helpful to pilots who wish to learn new techniques such as take-off, landing, gunnery, maneuvers and even fighting tactics. It also allows third parties to contribute performances that demonstrate basic techniques or tactics, while at the same time explaining what his being done. When the pilot-in-training has reviewed the track, he has the option to play it again and, at the moment of his own choice, pause the action and take over the controls himself.

In essence a training mission is a track that is no different from an ordinary track, except that it is stored in a special location and has an associated text file with the messages to be displayed and the track time at which they should be displayed. As was mentioned, another important difference is the the ability for the pilot to take control during the track. Several well done training missions come with the boxed version of *IL-2*. However, as with normal tracks the training tracks are dependent on computer performance and in particular on the patched game version (see section 9.6.4). Since the flight and damage models and other important factors influencing track playback are different between the various patched versions, you are very unlikely to be able to see the intended action in a training track made under a previous version when using a patched version of the game. This means that once you have patched the game to say version 1.2, you will not be able to view the training tracks that come with the game. Actually you will be able to view them, but you are likely to see aircraft colliding with the ground, missing targets and other erratic, unintended behavior. In section 9.14.1 a method of installing parallel versions is described that allows you to view training tracks from previous versions without having to reinstall and re-patch the game.

9.7.1 Installing new training tracks

It is relatively simple to install training tracks that have been sent to you or that you have downloaded over the Internet. It is a simple matter of installing a couple of files and editing one line in a text file. Training tracks are located in the`IL2 Sturmovik\Training` directory and consist of two files: the `.trk` (track) file and the `.msg` (message) file. To add a training track, you must place the `.trk` and `.msg` files in the `IL2 Sturmovik\Training` folder. In order for the *IL-2* program to know about a training track and appear for selection in *IL-2*, its name has to be added to the list of training track files. To do this, open the file`IL2 Sturmovik\Training\all.ini` and add a line in the list with the name of the track. It is important that this line match the filename (without extension) of your `.trk` and `.msg` files. Training tracks available at the Eastern Skies website contain a `readme.txt` file highlighting this procedure.

9.7.2 Making training tracks

Making training tracks is not much more complicated than making a regular track. However, making a good quality of training track can become very time consuming, and not many invest this time. The first step is to make a track that is useful but not too long. In order to make the quality of the track high and its length short, you might consider using the Full Mission Builder to design a mission for yourself. [3] It is advisable to place a few stationary cameras in order to make interesting views. Once your mission is ready you may need to fly the mission a few times to get it to your satisfaction (or correct the mission design), and once you have what you want you should rename the best version of the track to something recognizable.

[3] If you do this, you also might consider including the mission with the training track for distribution, though this not be of interest to a large number of people.

Now that you have the track ready, play it back with `Inflight Messages` enabled and be careful to write down the time in minutes and seconds when interesting events take place. Be as thorough as you can to save yourself from having to review the track over and over. Once you have written down the timing of important events, you can start writing messages for the student to read in the `.msg` file. The file should start with a line consisting of the text `[all]`, and each line after that should contain a time followed by the message, for instance:

```
0:01 Hello, pilot.
```

Once you think you have some useful messages, it is time to put the finishing touches on your track. Play the track back again and consider what views you would like. Feel free to experiment with editing the views so that the track becomes more interesting to watch. Be sure to always keep a copy of your original track so that you preserve a copy of the views as you saw them when flying. Use external and fly-by views, and if there are other aircraft or ground perspectives, show them as well using `Shift+F2` and `Ctrl+F2` for external views and the stationary cameras you have planted. When you are finished, stop track playback (or let the track finish) and save the track with a new filename.

As you change views and add comments you are likely to get ideas about how to place views and comments together to highlight aspects of the training method you wish to bring across. You might want to pan around the instrument panel, show the attitude of the airplane during a maneuver, or zoom in and out, all the while making comments. Be sure to leave the student enough time to read the comments. It is likely that you will need to make several tries to get the views just the way you'd like them.

Another consideration about using the viewing system is at what point you would like to enable manual viewing. You might leave `Manual View Control` disabled (radio button in the down position) and then enable it at some point in the track (press `Esc` to get the menu to do this). Once you enable manual viewing while playing back a track, you will not be able to get back the views you had while you were flying. The best you can do is to try to recreate them.

Once you have mastered the viewing and gotten the `.msg` file complete, you are finished. Write up a `readme.txt` file to accompany them and explain how to install them, zip them together and send them or upload them. Think of having someone review them for you if you feel brave.

9.8 Quick Mission Builder (QMB)

For some people this interface is completely intuitive, for others confusing. 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: only a handful of the several maps are available there. The QMB as a 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. A more flexible 3rd party tool, the Uber Quick Mission Generator (UQMG), has been developed by UberDemon.

The QMB works as follows. In the upper right-hand corner there is a toggle switch that allows you to select whether your side will fly as red (red star) or blue (iron cross), the default being red. This will determine the color of icons and set you to be either Russian or German by default. Below this, the screen is divided into two sides of four flights each, beginning with the flight you will lead. The first side is made up of `Your Flight` and three flights under `Friendly`. There are then four enemy flights under `Hostile`. Each of the flights on both sides is able to contain zero to four aircraft, for a total of maximum 16 aircraft per side or 32 aircraft total. From the pull-down menus you can select the number of aircraft in each flight, the AI skill level of the flight, the aircraft type and the loadout. All aircraft in the flight will share these characteristics. This means for example that, per side, there is a maximum of four different aircraft types available.

Besides the aircraft selections, you can set the environment and limited mission parameters. Altitude, weather and time of day are understood easily enough.

The map selection is limited to the Smolensk, Moscow 1 (winter as opposed to summer) and the Crimea maps. The basic reason for this is because there is a lot of work involved in preparing all of the possible waypoints and aircraft permutations possible in the QMB for each map, so a limit was set at three maps. The disadvantage of this is that other maps are inaccessible except through use of the FMB or campaigns/single missions. The UQMG and downloadable missions helps make these maps more readily accessible. It is also possible to download 3rd party campaigns or to purchase campaign packages.

QMB missions always start in the air, usually with the two sides not quite able to see each other and separated by perhaps 7 km. Flights on the same side will begin in formation with the same heading and grouped together. The opposing flights will also be in formation and heading toward you. The options advantage or disadvantage under `Situation` apply to your side. If you select advantage, all flights on your side will have an altitude advantage of some few hundred meters over the other side. If disadvantage is selected, you will be lower, and if none is selected, you will each start at the same altitude.

The QMB assigns waypoints in a standard way that provides for engagement of the opposing sides, and then leads the aircraft back to an assigned airbase, the red airbase located to the east and the blue airbase to the west. Aircraft that survive the encounter will thus follow the waypoints and land. Selecting an item from the pull-down menu `Target` will create waypoints around either an armored column, bridge or airbase at a predetermined location on the map. This will give ground attack aircraft on your team something to shoot at, and the aircraft on the opposing side something to defend. Selecting the default value of none means that there will be no ground targets, and the aircraft will maintain altitude until engaged or commanded by yourself, or until they descend to land.

Selecting AAA under `Defence` will generate anti-aircraft batteries around the area of engagement.

The buttons at the bottom of the menu are as follows: `Back` returns to the main *IL-2* menu; clicking on `Load` takes you to a menu where you can load previously saved QMB mission selections; clicking on `Save` takes you to the same menu and allows you to save the current QMB selections under a ”Quick Mission Name”; the `Difficulty` button takes you to a screen where you can specify the difficulty settings for the mission; and clicking `Fly` loads and starts you flying the mission.

Whenever you would like to exit the mission, press the `Esc` key. From that menu, select `Quit Mission`. From that menu you have the possibility to change most of the video, sound and control settings, or to return to the mission. Once you have clicked on `Quit Mission`, you are presented with a quantitative summary of the mission results. You also have the opportunity to save a track of the mission for future playback, to refly the mission exactly as it was generated before, or, by clicking `Done`, to return to the QMB menu to make changes or return to the main menu.

9.9 Single missions

Single missions are missions without a larger context, that is, that do not belong to a campaign. Otherwise, single and campaign missions are identical in their structure. To fly a single mission is trivially simple. Click `Single Missions` from the main menu, use the country and mission type filters, select the desired mission by left-clicking it, and click `Brief`. This brings you to the briefing screen, where you will see a map with your waypoints and mission objectives, accompanied by a briefing text. You can also set the difficulty settings for the mission and, under `Arming`, change the payload, weapons convergences and delays and fuel. When ready to fly the mission, check all systems, strap on your harness and click `Fly`.

A number of well-designed single missions are included in *IL-2*, and a much larger number are available for download at various sites or from individuals online. Additionally, you can create your own single missions using the FMB (see section 9.12. This leaves the question of where to put the things once you've gotten them.

In the *IL-2* root folder, there is a folder called `Missions`. If you can, go ahead and open up a file manager and have a look at the `Missions` folder. This folder has a specific subfolder hierarchy, and contains in its first level three folders: `Campaign`, `Net`, and `Single`. You can guess what goes in the `Campaign` folder; more on that later. The `Net` folder contains further folders for online missions, of which there are two types: coop and dogfight. The `Single` folder is the folder we are currently interested in, the one for offline single missions. Under the `Single` folder are nationality folders, originally in *IL-2* there is DE for Deutschland (Germany) and RU for Russia.[4] Under these nationality folders there are further folders—the default folders represent the aircraft you are meant to fly in the mission. This is, however, not restrictive: you can add as many additional folders at this level as you wish, and call them anything you like (within the accepted character conventions). That is to say, at this level you can organize your missions into categories according to your own purposes. It is into these folders that the single mission files should be written. (See below for more information on the files.)

The `Mission` subfolder hierarchy is strictly fixed to into the three categories, the `Single` folder is divided into countries (although this could technically be represented as some other category), and in each country any number of desired categories can be introduced. There is a restriction that this subcategory can only be one level deep. Subfolders such as `Missions\Single\RU\IL-2\training` will be ignored. The subfolder `training` is too deep, and mission files located there will not be found by the program.

From this hierarchy it should become clear that in the `Single Missions`

[4] It is actually possible to create new nationalities at this level, although there is more to it than just adding a folder.

menu the player simply specifies where the program should look for the missions. The program will start looking in the `Missions\Single` folder, and produce a pull-down menu corresponding to the country folders that are present. Once this is selected, the `Mission Type` list consists of the subfolders under the country that exist, and for the selected `Mission Type` folder, the mission files present in that folder are listed. When saving and loading files in the FMB, this hierarchy must be respected. In addition, the folders must exist before *IL-2* is started in order for them to be read.

There are two files associated with each mission: the `*.mis` (mission) file and the `*.properties` file. These are ASCII text files with a common base name (e.g., `mymission.mis` and `mymission.properties`) that can be read and edited in a text editor, and are generated by the Full Mission Builder. They belong together in the same directory. The properties file contains the mission description and briefing displayed in *IL-2*, and the mission file contains all other, such as the environmental conditions, objects used and their locations, waypoints, etc.

9.10 Pilot career: campaigns

The campaigns in *IL-2* are covered in some basic detail in the *IL-2 User Manual* [7], with introductory text providing overviews of the battles in the campaign setting, beginning on page 46. On pages 58–63, the manual describes: how to start a pilot career, how to interpret the mission briefings, prepare the aircraft with arming settings, give commands to wingmen, and the difficulty settings.

One reason why so little information about campaigns is provided is that there is very little to the them, in the sense that they are quite static. This means that the missions you fly are prepared in advance, and the sequence is completely fixed in the structure of the campaign. The only variation is that a given mission slot may be filled by one of two or three alternative missions that can be used instead of just one. The missions have variety, are well designed and fairly imaginative, and will still provide you with action and realistic challenges. However, there is no dynamic nature to them whatsoever, and this is generally regarded as a major weakness of the campaigns. The wonderful detail of the flight and damage models, along with the dynamic and difficult nature of air combat help compensate for this static campaign structure, but if you do a lot of offline campaigns, sooner or later it will not be enough. There are several very wonderful campaigns available for download and purchase, but you will not be able to fly a dynamic campaign, wherein the results of the previous mission affect the status and goals of the current mission.

9.10.1 Campaign hints

Think carefully about what difficulty settings you choose at the beginning of the campaign, as you won't be able to change them during the campaign. The `campaigns.ini` file in the pilot folder that determines the settings cannot be edited except by the *IL-2* program.

All of the missions involve flying to and from the target area, usually by means of the waypoints provided. For most missions this involves not much more than a short hop. By the standards of the Pacific Theater, a 50-minute flight to target is almost desperately close, but on the Eastern Front a 50-minute flight to target is abnormally long: the air forces were used to support the front lines and kept within close striking distances. I have learned to derive great pleasure from flying the aircraft to the engagement area, and some of the most exciting moments come from coaxing a damaged crate back to a friendly airstrip or workable crash site that can get your pilot home safely. Still, the virtual pilot is not a full-time pilot, and doesn't always want to spend 5–20 minutes to the target and then the same stretch back. What's more, there is a logical error in many of the campaign missions that causes your flight to climb and cruise at nearly maximum performance. This makes it difficult for the aircraft to form up and fly together to target, especially when you are not the flight leader. The AI-controlled aircraft do not have the same modeling and can fly without overheating, but not so your aircraft. It's not such a "hot" idea to fly at max power and arrive at the engagement area with a nearly overheated engine.

You can compensate for time-to-target and formation/overheating problems by using autopilot and time acceleration. Although this really doesn't give you the feeling of being a pilot flying over the front lines, it can save some nerves when you are having trouble keeping up with your group or spending more time than you'd like getting to and from target. However, be warned. The autopilot is known to occasionally fly you straight into the ground or a mountain, and can even cause aircraft to crash while in formation. Time acceleration can be dangerous too, especially at high speeds. It's easier for bandits or even the engagement area to sneak up on you (unless you're watching icons on the map) at higher time acceleration. In addition, the tracks often do not always play back correctly when recorded at the higher time accelerations. This may or may not be computer-system dependent.

9.10.2 Campaign installation

Concerning the installation of campaigns, these should always come with explicit installation instructions. If they do not, write to the campaign author(s) and ask for them. Installation is usually not difficult at all, but cannot be taken for granted. The structure for campaign missions is identical for all campaigns, but different authors sometimes have special touches that they add on.

The file structure of the campaign is quite similar to that of single missions in section 9.9. Under the folder location `Missions\Campaign` come country folders, by default only DE and RU. In the country folders are several files, including `all.ini` (containing a listing of the installed campaign folders) and several award and rank (promotion) files. Under the country folders are also the campaign folders themselves. *IL-2* comes with only three campaigns: one for the *Luftwaffe* fighters (starting with the Bf-109), one for the *VVS* ground-attack aircraft (Il-2) and one for the *VVS* fighters (starting with the LaGG-3). In the version 1.04 patch, a campaign for the newly introduced Bi-1 rocket was added. Additional campaigns will require an additional folder and identically named entry in the `all.ini` file. Inside of the campaign folder come all of the mission and corresponding properties files used in the campaign, plus an `info.properties` file that provides an introductory text and a `campaign.ini` describing the order of the missions (and any random substitution in a mission slot), plus the tracks to be played between missions. These tracks should be installed in the `Intros` folder, located under the root *IL-2* folder.

9.11 Multiplay: flying online

9.11.1 Dogfights

9.11.2 Coops

9.12 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.

If you start out using only the official notes from the *IL-2 User Manual*, 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. What is needed is a more detailed, user-friendly description, but a description of the basic user interface, features, tips and tricks of the FMB requires a fair amount of written material. An online guide[5] has been provided that attempts to cover the necessary basics and add a few helpful tips. The bulk of the guide was both written and compiled by Pomak249, with some editing and a couple of sections contributed by michapma. It is available on the host site Eastern Skies. Unfortunately, the material there does not provide an ideally user-friendly description and has not developed into the definitive guide to the FMB, but should nevertheless provide a good springboard to the powerful, fascinating and addictive FMB. Questions not covered by the guide, and hopefully these won't be basic, can be asked at the Mission Builder Forum (see section 11.1).

9.13 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.

9.14 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

[5] Previously, an excellent guide to the FMB had been written by Sotka and was hosted at Sturmovik Technika. When that site closed, the guide was closed with it.

official site. This list also provides links to locations where the patches are available for download.

How to install the patches

(this patch file is meant to patch over version 1.0, the boxed version)

Why I should install the patches.

9.14.1 Installing parallel patch versions

For reasons of viewing tracks, continuing campaigns using consistent flight and damage models, or comparing the various patched versions, you might consider installing more than one patched version of *IL-2* on your computer. This is fairly easy to do. It is usually not at all necessary to reinstall the program. *IL-2* is not dependent on entries in the Windows registry. To make parallel installations, simply create a parallel *IL-2* folder in a new location (such as in the `Ubi Soft` folder) and copy the entire contents of the existing version of *IL-2* that you would like to use as a basis for the new version. This is probably best understood through an example.

Let's assume that you have installed *IL-2* from the box and enjoyed flying partway through a campaign, but have now discovered that you can patch to version 1.2. What to do? In this example, make a new folder under `C:\Program Files\Ubi Soft` named `IL2 Sturmovik 1.2`, which will be parallel to the original installation folder `IL Sturmovik`. Next, copy (not move) *all* of the files in the folder `IL Sturmovik` into the new folder `IL2 Sturmovik 1.2`. Voilá! You now have two parallel installations of *IL-2*. To actually make the new version into version 1.2, you should apply the appropriate patches to folder `IL2 Sturmovik 1.2`. Namely, you should download and execute first patch file `il2upgrade_1.1a.exe` and then the patch file `il2upgrade_1.2.exe` to folder `IL2 Sturmovik 1.2`. These two versions of *IL-2* will now be completely independent of one another. However, you should be careful to update the links located on your desktop and/or under Start ▷ Programs.

CHAPTER 10

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?! And how do I take a screenshot and look at it? Don't worry, you aren't the first to have technical issues. 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.

10.1 Screenshots

Taking screenshots in *IL-2* is easy, you just press the `PrtScr` key while the action is right. Of course taking good screenshots is a bit of an art: finding the right angle for the shot, getting the graphics settings right and so on. Some tips are to use tracks to play back the action (this can take some patience on longer missions while waiting for the track to play back to the right point), slow down the action (use the `[ key` to get just the right moment and then pause (`P`). You should use `F2` and `F8` to get the right external shots.

Now for the technical side. The shots themselves are dumped by the game to the system root folder, the default location is

`C:\Program Files\Ubi Soft\IL-2 Sturmovik`

They will be in the Truevision Targa (TGA) format and listed sequentially as `grab0000.TGA`, `grab0001.TGA`, etc. This format is an uncompressed bitmap of the screen image and gives a very accurate representation of what was on the screen. Its disadvantage is that the file size can be enormous; as an example, a 1280×960 resolution with 24 bits per pixel renders a file size of 3.5 MB. A simple conversion to a compressed file format such as JPEG (without compression or smoothing) results in much smaller file sizes, depending on the compressibility of the image. A shot that contains mostly blue sky will compress much better than one from a cockpit with a landscape outside. A typical conversion size for the above example is around 400 kB. There are several good quality freewares available on the Internet for conversion from the TGA type.

Another very important note about screenshots is that the screenshot sequence counter is reset when the *IL-2* program is restarted. This means that if you leave the program and restart, the first screenshot you make will be named `grab0000.TGA`. If previous screenshots have not been moved from the root folder or at least renamed, they will be overwritten. It is a good idea is to create a folder structure in a safe place (preferably in a different location than the *IL-2* program folders) and an equally good habit to develop is to move all screenshots from the root folder every time you exit *IL-2*. You might consider structuring your screenshot directories according to date, campaign, or whatever is logical for you. If you like most take large numbers of screenshots but don't feel like editing and converting every one of them, it is relatively low maintenance to compress them for archiving (such as with WinZip) them and write them to a permanent backup medium such as a CD. The TGA format compresses quite well, again depending on the nature of the information in the screenshot.

Note that excessive screenshot capturing during online play can cause severe lag. A limitation of about one screenshot per 10 seconds has been set to reduce this problem. (In *Forgotten Battles* the capture of online screenshots without inducing lag has been largely facilitated by the introduction of online tracks, so that screenshots can be made after the action.)

10.2 Terminology

frames per second, antialiasing, anisotropic, etc.

10.3 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 9.5.1, 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.

10.3.1 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

10.3.2 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
```

10.4 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.

10.4.1 Known issues

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

10.5 System performance

10.5.1 System requirements

10.5.2 CPU

10.5.3 RAM

10.5.4 Graphics card

10.5.5 Hard disk

10.6 Multiplayer 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.

10.7 Useful external hardware

Joystick, throttles, rudder pedals, TrackIR

10.8 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 11.1).

CHAPTER 11

The *IL-2* community

11.1 The official forums

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

- General Discussion
- IL-2 Squadrons
- IL-2 Community Help
- Oleg's Ready Room
- Paint Schemes Forum
- Mission Builder Forum
- Movie Makers' Forum
- Chat Room

11.2 Online resources

It is possible that short reviews of relevant websites and online resources are beneficial here. There is a short list of links at Eastern Skies, which will at least lead to sites with more complete list of links.

11.3 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 [real life] 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)

11.4 Squadrons

Some of the best online experience comes from flying with pilots you know. You can do this by chatting with others in dogfight and coop servers, and discussing on the forums and making arrangements to fly and even get on comms. For a regular online experience though, it is hard to beat participating in a squadron. In a squadron you will undoubtedly learn a lot about many subjects from more experienced pilots, but more importantly you will *have fun*. And this is what squadron participation is all about. Different people have fun in different ways of course. Some enjoy themselves by simulating historic conflicts and using the tactics they read about from the war. Others just want to get up in the air and go crazy. There is no right way, so once you've found out what you like to do, talk to others and find a squadron that you think you'd like to join.

Most squadrons have a trial period for new people applying for membership, something like a few weeks. This is not really a trial in which you have to prove yourself, but more like a period of time in which you get to know the squadron and observe their activities. The purpose is usually to provide potential members with an opportunity to graciously back out if they find out for any reason that squadron activities aren't what they had hoped for. There are enough squadrons out there, so make sure you find one suitable to you. You'll be happy you did.

There are a few other advantages to belonging to a squadron besides regular online activity and having a group to learn, joke around and conspire with. One big plus is teamwork and immersion. The use of online voice comms can be very immersive, and learning and employing team tactics is one of the most challenging and enjoyable aspects of air combat. Squadrons can also participate in public and private competitions and online wars, and squadron activity opens doors to meeting pilots from other squadrons. There are of course potential disadvantages to squadron participation too. For example, most squadrons require some minimal regular activity from their members. However, squadron leaders understand that real life comes first, and are flexible.

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Main Menu
John 'Mad' Doe
Single Missions
Pilot Career
Multiplay
Quick Mission Builder
Full Mission Builder
Training
Play Track
Quit
Pilot Roster
Pilot
John 'Mad' Doe
Controls
View Objects
Credits
Hardware Setup