

FlightGear Flight Simulator – Flight School

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FlightGear Flight School Version 0.0.3

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Manual was written for *FlightGear* version 0.9.3.

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Preface

Welcome to the fascinating world of Flight Simulation - and welcome back to school! Flight simulation can be a very nice hobby. You can just do a short flight during lunch time break in the office, but you can also do a 'professional' pilot's job, including flight planing, checking the weather, calculating the fuel consumption, programming the FMC, et cetera. In both cases you need at least some basic knowledge of what you are doing.

I tried to set up this tutorial to be as easy as possible, but also as comprehensive as possible. Hopefully you should be able do to simple 'go arounds' after reading only the second chapter. In the following sections we will go deeper into flight planing, navigation, instrumentation and other aspects of flying. But You will also get to know all different airplanes available in *FlightGear*, even uncommon ones like a balloon or an ufo.

This tutorial is part of the whole *FlightGear* documentation.

- *FlightGear* Installation and Getting Started
- *FlightGear* School
- *FlightGear* Scenery and Aircraft Design¹
- *FlightGear* Programmer's Manual ¹

Finally I want to say 'Thank you' to all the people that made this wonderful piece of software. You really did an excellent job. Also I have to thank all people giving me feedback and comments to this tutorial.

Disclaimer Even though we tried to make this tutorial as real as possible, it is not for real world flying. Using it for any other purpose than entertainment is at your own risk.

Carsten Höfer, October 2003
(carsten.hoefer@t-online.de)

¹not written yet

Chapter 1

NOTAMs

This section is more or less for internal use. I will list here all changes since the last version, will give comments to special topics or simple ask for help or information for some sections.

I will keep the notam entries as long as I still need information. So please also read the sections of previous releases.

Version 0.0.3

- **Menue:** Due to its explanation in the Getting-Started-Manual, I've deleted the section about the menue.
- **Helicopter:** We now do have helicopter support in *FlightGear*. Therefore I've added a section about flying these.

Version 0.0.2

- **History:** I've tried to add a brief history of aviation. Unfortunately my knowledge of history is very limited. Especially if it deals with anything besides the 'big milestones' or outside Germany. I do not have any information concerning the development of helicopters either.

Version 0.0.1

This is only the basic structure of this flight training. To give you an idea of what's planned, I've added at least an abstract for each section.

You will notice that I've also included program options not yet available in *FlightGear* like ATC, multi-player mode, combat simulation. But even if they are not implemented, I think, there are some interesting points to know and learn. Also I am absolutely convinced *FlightGear* will have all these options in the future.

I have to confess to be only a computer pilot. I have no idea how it is to fly a real plane and whether any sim is comparable. Therefore I guess I will put a lot of wrong things in this tutorial. Also English is not my native language (I think, you've noticed already). Please send me corrections and 'bug lists' as much as possible!!

I did mention above to use this NOTAMs also to ask for help. So here is my list, where I need your help and assistance:

- **Airplanes:** For the section about the airplanes I need to have as much technical information as possible. So if you know something about speed, climb rates, fuel consumption, engines, FMC, equipment, history, et cetera, please send it to me. If you know someone at Boeing or Cessna give him (or her) my e-mail address and ask him (or her) to contact me.
- **Checklists:** To make the simulation as real as possible it's necessary to have real checklists for at least the essential parts of the flight. If you have or can get any checklists or procedures, please send them to me.
- **Combat strategies:** I do not know anything about flight combat and its strategies. If someone out there is an expert, please feel free to write the section about combat.
- **VFR:** For the chapter explaining VFR I would like to have a really good scenery, so that VFR flying and navigation with checkpoints is possible. Do we have any?
- **Links and Bibliography:** If you know any good links, books, magazines or whatever, please tell me and I will add them to the list.
- **Translations:** The main document will be the English one. I will also try to work at the same time on the German translation. If you would like to have this tutorial in your favorite language as well, please feel free to work on it.
- **Help:** Setting up the structure of this document, I was surprised how much I would like to put in it. For me it looks like a decade's work. So everyone is invited to send me articles or sections for this tutorial.

Part I

Basic Flying

Chapter 2

Basics

2.1 *FlightGear* Fundamentals

2.1.1 Installation and Start

The installation of *FlightGear* either as pre-built binaries or as source code, that has to be compiled, is well documented in the Getting-Started-Manual[5].

As long as there is no menu structure to choose Aircraft within *FlightGear* the best is to start the program out of a shell¹. This enables the user to pass different options to *FlightGear*. These options will be explained in later chapters when needed.

Simply start the simulation according to [5].



Fig.: Starting Screen of *FlightGear*

¹MS-Windows: Start-Programs-?????

2.1.2 Overview

When the program starts, you will sit the first time in your aircraft, which should be a Cessna 172 by default. Right in front of you, you will see the cockpit with all different instruments, switches and knobs. Looking outside you will see the airport of San Francisco Intl.(KSFO).

Pressing shift key and numeric keys according to the following table, you can have a look around²:

Shift+8	Forward
Shift+7	Left/forward
Shift+4	Left
Shift+1	Left/back
Shift+2	Back
Shift+3	Right/back
Shift+6	Right
Shift+9	Right/forward

Maybe you feel a little bit disturbed by the engine sound. Either press [p] for pausing the simulation or press [??] for muting the program. Hitting [v] will toggle between views from the cockpit, from a chasing aircraft or from the tower. Especially for the tower view sometimes it helps a lot to find the aircraft by zooming in [x] and out [X].

Back to the cockpit view, you can switch it off completely by [P] or reduce it to the important instruments only by [s].

Most of these keys work like on/off switches. For example, pressing [P] once will hide the cockpit panel, pressing [P] a second time, will display it again. Most of the defined keys and commands will be explained when needed during this tutorial. The user who wants to jump into the program directly should read the Getting-Started-Manual[5] or the Short Reference[6].

2.2 Physics of Aero- and Flight Dynamics

Isn't it astonishing, that heavy airplanes like a Boeing 747 with a take off weight greater than 400tons is able to fly? Sure, but only at a first glance. If you look more closely to aerodynamics and physics, than it's obvious, what keeps the plane up in the sky.

2.2.1 Air

Let's have some word on the medium we will be flying in: Air!! This may sound very trivial (and in fact is), but is essential for every flight. Details on weather will

²NumLock must be off

be discussed in 13.

Air is a mixture of different gases. It consists of approx. 78 vol-% nitrogen, 21 vol-% oxygen and 1 vol-% of inert gases (helium, argon, neon) and carbon dioxide. In addition to this, air also contains some water vapour (0 vol-% to 5 vol-%). Depending on this humidity the percentage of the other gases varies[2]. Due to the weight of all these molecules in the air a certain pressure is acting on all bodies within the atmosphere of the earth. Also on the air itself. Because of the compressibility of gases the pressure causes different densities of the air depending on height. Also the weather changes the air density. In later sections we will see, that this density is important for many aspects of flying. Many of the instruments of an aircraft work with air-pressure or pressure differences, which is depending on density and also the efficiency of the engine is depending on the density.

2.2.2 Four Forces

Basically there are four forces acting on an airplane in flight: Lift, Weight, Thrust and Air Drag. Always two of them are loading the plane in opposite directions: Lift and Weight, Thrust and Air drag. In a 'normal' horizontal straight flight these four forces remain an equilibrium. This means, the plane will not descent nor climb or decelerate nor accelerate.

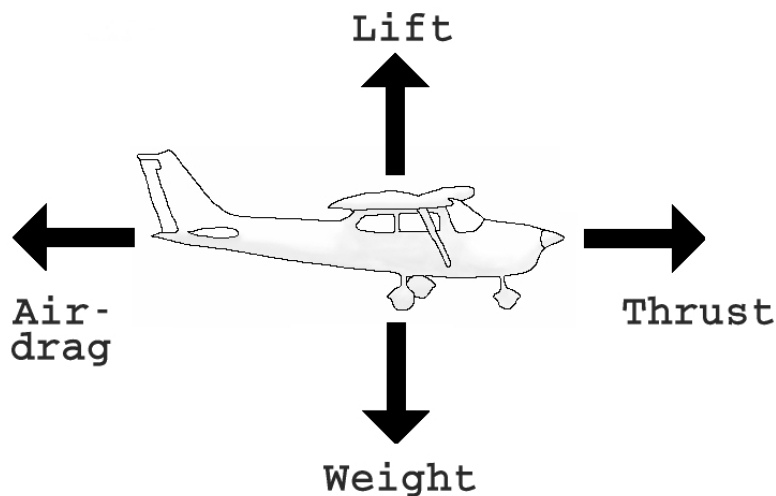


Fig.: Plane with four12 resulting forces

Lift

Lift is the force pulling the aircraft up (most of the time). When a body moves through air or any other medium and this stream is not exact normal to the body, it will be moved either up or down. For example, when you move your hand out of the window of a driving car and you turn it a little bit that the front side points

upwards, your arm will raise. This effect may be enhanced by profiling the body. The wings of a airplane are not flat but curved. If now the wings (means the aircraft) move through the air, the air is divided by the front of the wing. Due to the profile of the wing, the air at the lower side has to move a shorter distance than the air streaming around the upper side of the wing. To maintain the equilibrium the upper stream has to be accelerated. The faster upper stream causes less pressure to the wing than the slower lower stream (sentence of Bernoulli: The product of pressure and velocity remains constant; $p \cdot v = \text{const}$).

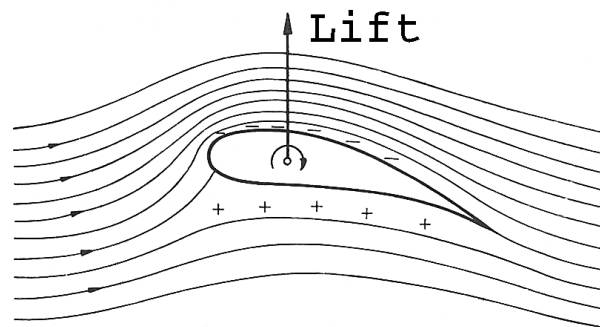


Fig.: Wing with streamlines and resulting Lift[9]

This difference in pressure on the wing results in a lifting force. The Lift is always pointing normal upwards to the wing.

The force is depending on several parameters like the wing profile, the velocity of the plane relative to the air, wing forms, the area of the wing, air density, et cetera.

Weight

Weight is the opposite force to Lift and is always pointing towards the earth.

Thrust

Thrust is the force moving the airplane in the longitudinal direction. In most cases (except hang gliders) the thrust is produced by one or more engines with propellers, turboprop- or turbojet engines. We will start here with simple propeller engines. Other types of engines will be discussed in the appropriate later chapters.

The power for the propeller is produced by an engine, that is very similar to car engines. The rotating propeller pushes the air backwards to the rear of the plane. Due to Newton's laws (lat. actio = reactio), this will generate a forward movement of the plane.

There is a concurring or additional explanation, why a plane is moved by rotating propellers. They are build out of two to four single wings. The expression 'wing' is not wrong in this context. Like the two wings of the plane also the propeller has a profile and produces 'lift'. The difference to the above described wing is, that the propeller rotates around the longitudinal axis of the plane. When the propeller

rotates the air moves around its profile, is diverted to the front (upper) and the back (lower) side of the wing. Thus resulting in a force driving the plane. Like the lift also the thrust is depending on the air-density. If the density is high, there are many air molecules that will be moved by the rotating propellor, causing a higher thrust. When we've successfully made our first starts You may compare the distance You need for take off at sea level with the one You need in high mountains. We will discuss this aspect later in the chapter Flight Planing??.

Air Drag

Opposing to thrust is air drag. It acts every time a body is moved through an other medium, like water, air or ice cream. It is depending on size, form and surface of the moving body, its velocity and the density of the medium.

Drag is divided into four different forms:

- Form Drag
- Friction Drag
- Induced Drag
- Interference Drag

Every body moving through air can be regarded as a hindrance to the air. The air is slowed down, has to move around the body and come together behind the body, causing whirls. The amount of this form drag depends on the form and the face of the body and the relative velocity. An expression for the form of the body is the c_w -value. It describes the relative drag to a flat plate (c_w of 1). A sphere reduces the value to 0.5. Very good is a drop like form resulting in a value of 0.05 with the same facing area.

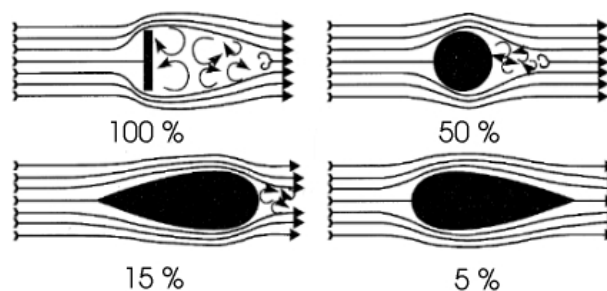


Fig.: Different forms with according air drag and c_w -value [1]

While drag is proportional to the size of the facing area, the velocity has an quadratic effect. If the velocity is doubled the drag increases by four. Form drag is the biggest of the four drag types.

This advises the air plane designer to give the plane a low form drag, for example

by usage of retractable gear.

When the air moves around the body there is friction between the air and the body. The amount of friction depends on the quality of the surface. Painted or varnished surfaces give a very low friction drag.

The differences in pressure between the upper and the lower wing surface is compensated at the lateral end of the wings. This compensation causes whirls or wake turbulence behind the airplane. These turbulence depend on the weight and velocity of the plane and the form of the wings. The largest amount of this whirls is generated by slow flying large planes (with full extended flaps). Besides the induced drag, these turbulence give also a big risk for following air planes. To reduce this risk the distance between to planes in the final approach can be up to several miles.

Today the designers try do minimize the induced drag by modifying the lateral ends of the wings (wing tips or winglets).

All parts of the plane generate drag. These drags interfere with each other. Sometimes neutralizing each other, sometimes intensifying each other. The difference between the theoretical drag of all single parts and the the effective drag is called interference drag. By creating smooth transitions between the single parts or appropriate facing todays designer try to reduce the interference drag.

The better the form and surface, the lower the interference and induced drag, the lower is the total drag of a plane. A very low total drag let a plane fly faster with less fuel consumption.

2.3 Airplanes

Disregarding of the size of a plane the general layout is the same for a small Cessna or a Concorde.

2.3.1 General Set up

Normally a plane consists of a tube like structure called the body. The body gives space for the cockpit, passenger and luggage compartments, electronics and more.

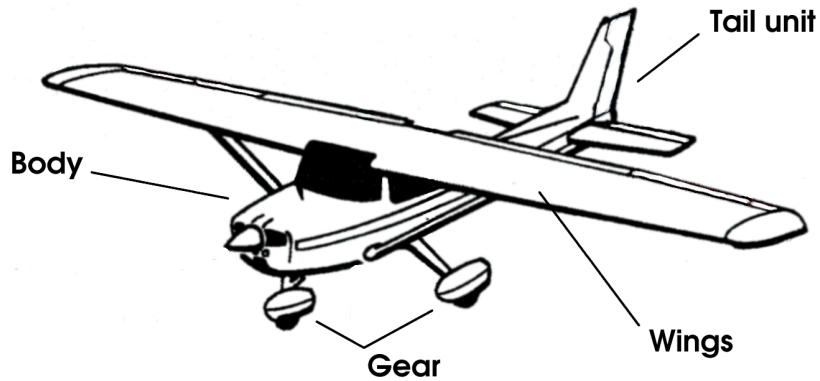


Fig.: General Set up of an aircraft

Mounted to the body one will find the wings, gear and the tail unit.

Mostly smaller airplanes are separated by the mounting points of the wings:

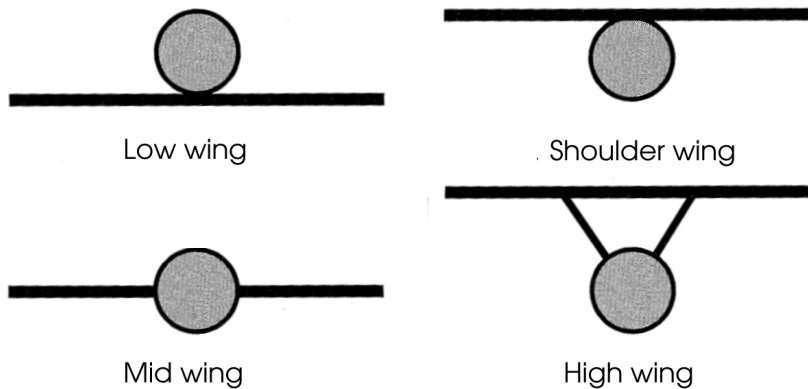


Fig.: Different types of wing forms[1]

The wings contain the fuel tanks, Flaps, spoilers and ailerons.

The tail unit is mounted at the back of the body. The tail unit contains the elevators and rudder. Normally the elevators are mounted lateral to the body and the rudder above. Besides this, there are T-tail units, where the elevators are mounted on top of the rudder and V-tail, combining elevators and rudder in two diagonal wings.

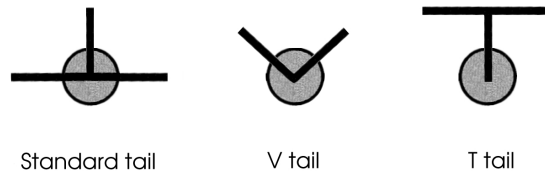


Fig.: Different types of tail units

Below the body or the wings one will find the gear. Advanced aircrafts have retractable gears to reduce air drag. Most of the planes have a single front gear and several major gears at the center of the plane. At lower speeds at the ground the plane is steered by the single front gear. Some smaller planes have the single gear mounted at the back below the tail unit.

The engine(s) are mounted either at the front of the body or at the wings.

2.3.2 Controls

Due to our improved knowledge of aerodynamics we now know, what makes a plane fly. But how to control it? In this section the basic controls of a plane are discussed. In later chapters we will see how they work up in the air.

A plane can move in all three dimensions, therefore there are six basic directions: up,down, left, right, front and back.

To make the plane go up or down one moves the yoke backward or forward. This will move the elevators mounted at the tail unit. If the ends of the elevators are moved upwards, the tail of the plane will be pushed downwards. The acting force is also the lift. The lowered tail will rotate the plane and therefore increase the angle between the plane and the streaming air (angle of attack). The plane will start to climb. But only for a very limited time. Than the plane will loose speed. The lift of the wings is depending on the speed and therefore the speed will decrease. It's like driving up a hill. When You do not increase the power, the car will slow down due to the ascent.

So for a permanent climb one has to adjust the power setting of the plane also.

To reduce height in most cases it is sufficient to reduce the power setting. The speed will reduce and also the lift.

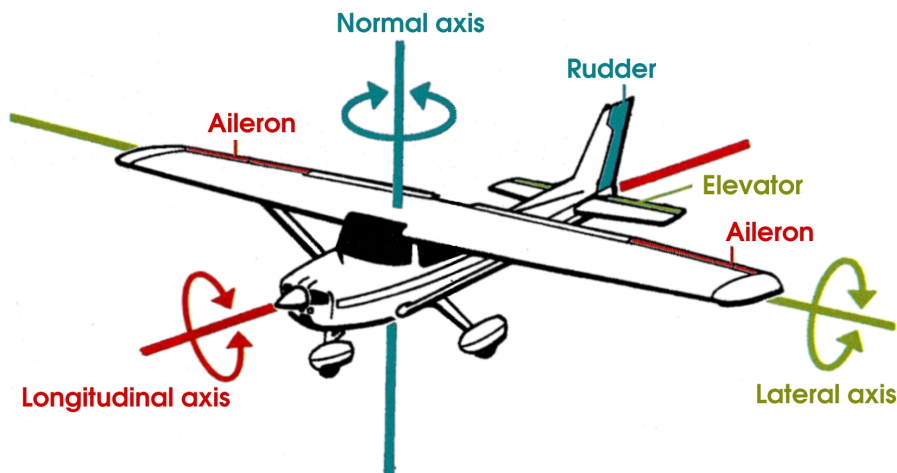


Fig.: General Set up of an aircraft ([4])

At the lateral ends of the wings one finds the ailerons.

Ailerons are controlled by the lateral movement of the yoke. Moving the yoke to the right, makes the left aileron point downwards and the right one point upwards. This causes the plane to rotate about the longitudinal axis. This bank will make the plane to fly a curve.

To rotate the plane around the normal axis one uses the rudder mounted at the rear end of the tail unit. The rudder will be controlled by the pedals. Pushing the right pedal will turn the plane to the right side, pushing the left pedal will turn the plane to the left side. Both pedals are coupled. Moving one to the front will move the other one to the back.

In smaller planes the pedals are also used to turn the plane on the ground. Bigger planes have a separate wheel to control the front gear.

The top ends of the pedals are used to activate the tyre brakes of the plane. Bigger planes also have 'air brakes', called spoilers. Spoilers are mounted on the top of the wings and destroy the current around the wings and increase the air drag. In addition to this heavier planes have thrust reversers to brake a plane on the ground. As the name implies, thrust reversers act as if the engine is switched to rear gear.

2.4 General Cockpit Layout

Like the general outer layout is similar for most planes it is quite the same for the cockpit. At least the bigger planes are equipped for two 'pilots': the pilot and the 1st officer.

In smaller planes like the Cessna 172 most of the instruments are placed in front of the left seat, while for the right seat there is only the flight stick. But due to the narrow cockpit, also the person on the right hand side is able to have a view to all instruments.

Besides the main instrument panel there are several more in greater planes. The main engine controls are mainly placed in the centre console, electrical instruments are also to be found in overhead panels or side panels next to the pilots and co-pilots seat.

2.4.1 Instruments

In front of the pilot one will find the most important instruments in the plane. Before looking at these instruments in detail, we will have a short look at the way they work. There are two different types of instruments: pressure driven instruments and gyroscopic instruments. Altimeter, vertical speed indicator and airspeed indicator are pressure driven instruments, artificial horizon, directional gyro and attitude gyro are gyroscopic instruments.

Pressure Instruments

Pressure driven instruments are basically very simple. It has a membrane, which is filled with air with a certain pressure. Outside of this membrane there is also air with a certain pressure. If these pressures are in equilibrium the attached pointer remains in a neutral position. If the outside pressure is greater than the inside pressure, the membrane will expand and the pointer will move, and vice versa.

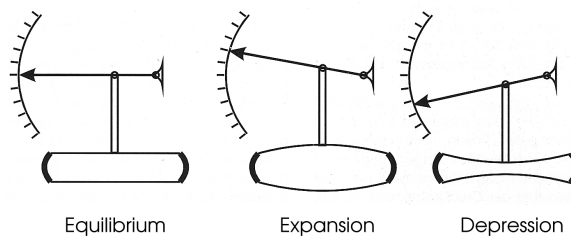


Fig.: Scheme of pressure powered instruments[1]

The advantage of this system is that it is independent of any power supply or anything else than the air pressure. The big(!) disadvantage is that these instruments are depending of the air pressure, which is never constant.

Gyroscopic Instruments

Do you remember spinning your top some years ago? Did you ever try to move a spinning top? There were high forces acting normal to your force. This is the principal of any gyroscopic instrument. They have a fast rotating kernel acting according to every change in position and orientation. For a gyro rotating with a

constant speed the re-acting force is well known and can be used for measurement. Unfortunately the rotating earth and the movement of the gyro also create these forces.

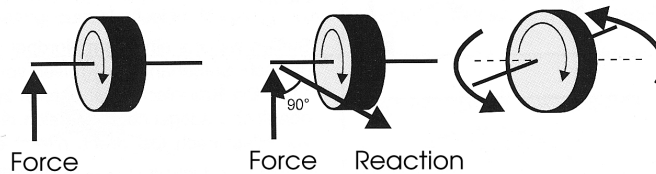


Fig.: Scheme of gyroscopic instruments[1]

Gyroscopic instruments are powered either electrical or by vacuum pumps, meaning that they always need electricity or a running engine.

The Altimeter

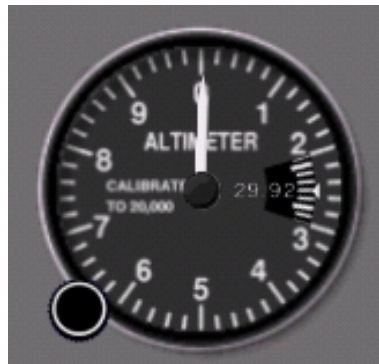


Fig.: The Altimeter

The Altimeter is used to give the actual height above MSL of the airplane. Actually it is not directly measuring the height but the pressure of the air outside the plane. Due to the decreasing air-pressure in greater heights, a difference in pressure can be interpreted as difference in height. The height is measured in feet³. The display is divided in 20 feet steps with numbers for every 100 feet. The short hand gives the altitude in 100 feet steps and the longer hand in 1.000 feet steps. 10.000 feet steps are displayed in a small window in the upper part of the altimeter. To adjust the current instrument settings to local air pressure there is a small knob (Kollman knob) at the lower left of the instrument. The actual setting is displayed in a small window in the middle of the left side of the instrument. Standard is 29.92 Inch of mercury (or 1013.25hPa).

The Attitude Gyro

The attitude gyro shows the actual climb situation of the plane. The scale is given in feet per minute (fpm).

³For unit conversion see I.



Fig.: The Attitude Gyro

The Airspeed Indicator

During a flight it is always important to know the speed of the plane. The instrument to show is the airspeed indicator. But even a 'simple' instrument like a speed indicator is complicated in avionics.

In a car it is quite simple to measure the actual speed. One knows the speed of the rotating axle and can multiply this speed with the circumference of the tyre and some other simple mathematical operations and get the approximate velocity.

But how may this be done in an aircraft? First of all one has to distinguish the different velocities of a plane. Different velocities? How is this possible? Sure a plane can only fly at one speed at a time. But in aviation there are several possibilities to measure this velocity.

- Ground Speed (GS)
- Indicated Airspeed (IAS)
- Calibrated Airspeed (CAS)
- Rectified Airspeed (RAS)
- True Airspeed (TAS)

The ground speed is quite similar to the velocity of a car. The distance between two points is divided by the time the plane needs for it and this gives the ground speed. In Aviation the speed is measured in knots (1knot = 1 nautical mile per hour)⁴

The airspeed indicator shows the indicated airspeed (that's where the name comes from!!!). Due to errors in the measuring system, loss in the pipelines, and other reasons the indicated airspeed is not the true airspeed. Taking all these errors into account one will get the calibrated airspeed (CAS, am.) or the rectified airspeed (RAS, brit.). The expression calibrated airspeed is commonly used.

⁴For unit systems used in aviation see I.

The differences between IAS and CAS are given in the airplanes handbook. In most of time the differences are quite small and therefore neglectible. Only in slow flying situations with higher angle of attack the difference may be up to 10-20 per cent. Sometimes You will see a 'K' in front of the speed expression (e.g. KIAS instead of IAS). This is only to emphasise, that the speed is given in knots.

The airspeed indicator is a pressure instrument and therefore once again the indicated airspeed is depending on air density. Unfortunately only in sea level (MSL) the calibrated airspeed is approximately the same as the true airspeed. Due to the lower density in greater heights the difference between CAS and TAS is increasing. The error is approximately 2 per cent per 1.000 ft[1]. In 4.000 ft the error is therefore 8 per cent. When flying with 120 kt IAS this means that the true airspeed TAS is 130 kt.



Fig.: The Airspeed Indicator

The scale of the airspeed indicator is color coded with a white area, a green area, a yellow area and a red line. These markings refer to several operating speeds. These areas are different for each aircraft.

White Area	Operation with flaps full extended. The lower boundary is the stall speed at maximum weight (VSO), the upper boundary is the maximum speed with full extended flaps (VFE)
Green Area	Normal operation. The lower boundary is the stall speed with maximum weight without flaps (VS1), the upper boundary is the maximum travel speed (VNO).
Yellow Area	Attention operations. Only fly with speed in yellow area in calm weather situations
Red Area	Maximum speed (VNE).

2.4.2 Overhead Panels

Bigger aircrafts than the Cessna 172 have an overhead panel. Depending on the plane one will find electrical instruments, switches for lights, air conditioning or engine controls in this panel.

2.4.3 Center Console

In the centre console one usually will find the controls for the engine and trimming. Also the auto-pilot or radios will be placed here.

2.4.4 Radio Stack

Usually the all communication instruments like radio, transponder and navigation unit (incl. GPS) are located in the same area. For the C172 You will find these instruments on the right side of the instrument panel.

Chapter 3

First Steps

After the first theoretical sections You are now up to take Your first practical lesson. The plane we will use is the 'standard' training aircraft all over the world. It's the Cessna 172P Skyhawk. You will find some details on the airplane in the aircraft sectionB.1.

3.1 Pre-Flight

Please start *FlightGear* using `'-start-date-lat=2003:06:08:15:30:00'` (this will prevent starting in the middle of the night) and load pre-saved flight `"flight001.sav"`.¹ You will find Yourself at the parking area of KSQL. It's a small local airport of San Carlos south east of San Francisco.

3.1.1 Airport

Before a normal flight it is always essential to make a very detailed and careful flight planning. We will skip this for the first flight and come back to this task in section 'Flight Planing' ???. To find the runway, we need at least a little overview of the airport we are going to start from.

For every airport there are a lot of different charts about the airport layout, departure, arrival, etc. We will use only a part of the airport chart for this time. You will find the full chart in G.

¹All pre-saved flights are located in `Docs/source/FlightGearSchool/saved_flights`. You have to copy this file to the starting directory before loading it.

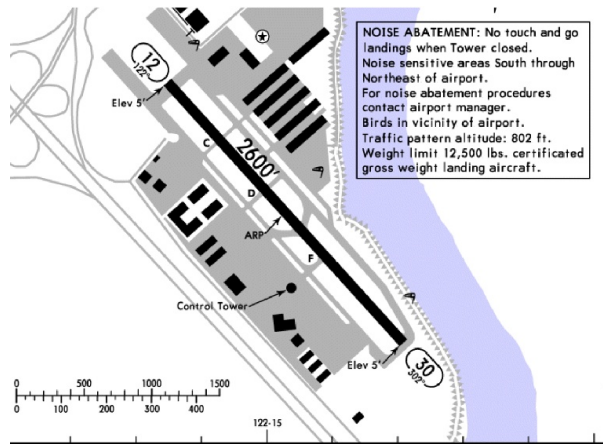


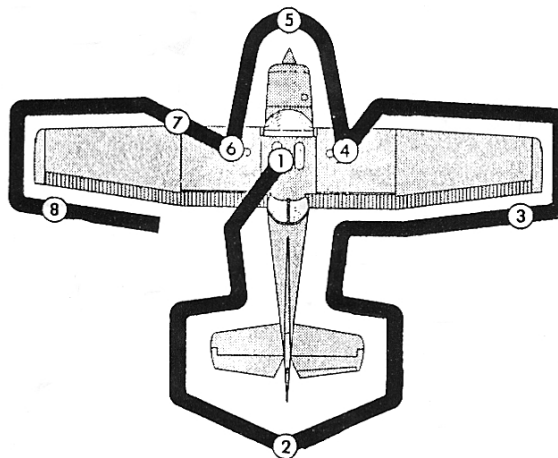
Fig.: Airport layout of KSQL

At the moment the plane is standing at the parking area near the figure '2600' right in the centre of the map.

You see the only runway (12/30) as a black line crossing the map. The numbers 12 and 30 multiplied by 10 give the approximate directions of the runway. Below these numbers You will find smaller ones giving the exact direction (122 or 302). For our first take-off we will use the runway 30. Therefore we have to taxi the grey taxiway north of the runway down to the begin of the runway. The long taxiway will give us some time to learn to control the aircraft on the ground. But first we still have to do some work.

3.1.2 Outside Checks

Before we enter the Cockpit and start the engine, there are some outside checks to do². Indeed this isn't really necessary or possible for a flight simulator.



²For detailed checklists see B.1

Fig.: Outside Checks[3]

1. **Fuel** In the Cockpit switch on the master switch, which You will find in the left lower edge of the panel (unfortunately this function is not yet implemented in *FlightGear*, just imagine using the switch).
 In opposite to our well know car, there are keys and a master switch. In a plane the engine ignition does not dependent on the battery or a generator. This is very important, because both may fail. Therefore the ignition get's the power directly from to magnetos at the engine. All other electric parts of the plane get the power from the battery.
 To check the fuel, the master switch has to be switched on, so the instruments gets power from the battery.
 At the left side of the panel You will find the fuel gauge. It should now show the actual fuel stand. For this time, the fuel tank is full. For a regular fly the pilot has to calculate the fuel before the flight. Taking too less fuel may result in a dangerous situation. Taking too much, will increase the weight of the plane, leading to Higher fuel consumption and worse flight conditions. In later chapters You will learn to calculate the fuel to take before a flight.
 Switch off the master switch again. This is very important. At the moment all systems of the plane take the energy directly out of the battery. Due to the engine not running yet, it is not loaded and will drain very soon.
2. **Tail unit** Are all connections of the moveable parts secured safely? Is the rudder easily moveable?
3. **Aileron** Ailerons shouldn't allow major movements in lateral direction, but should be moveable around the lateral axis.
4. **Main gear** Is the pressure of the tyres correct? The supplies for the brakes?
Fuel tank Is water inside the fuel tank? There are valves below the wings where one can take some fuel out of the tank into a small glass. Water weights more than fuel, therefore one can see, if there is water inside.
 The fuel gauges inside the cockpit are not very accurate. Therefore there are some fuel maesurement bars to check the amount of fuel manually.
5. **Oil** Check the amount of oil inside the engine
Propellor Check the propellor. Check for the keys. Rotating the propellor may start the engine! Please be careful!!
Lights Check the landing lights. The glass should be clear and clean.
Front gear Check for tyre pressure and working spring.

6. **Static port** The opening of the static port should be free and clean for working instruments.

Pitot tue For working airspeed indicator the opening of the pitot tue should be free and clean.

Stall warning opening For working stall warning the opening should be free and clean.

3.1.3 Cockpit

Back inside the cockpit, let's take a look around. Maybe you will not be able to see all of the instrument panel. You may click the left mouse button twice (until the mouse point will be changed to a double ended arrow) to use the mouse to change you view. But you also may will use the mouse for controlling the plane, this can be a little bit dangerous. Therefore click the left mouse button a third time to come back to normal pointer mode. Adjust yor field of view (Shift X-key) until you see at least all levers at the bottom of the panel. You will find a lot of instruments, we've already seen in previous sections.

Directly in front of You, You will see the 'holy six', means the altimeter, vertical speed indicator, airspeed indicator, artificial horizon, directional gyro and attitude gyro. You will find these most important instruments in all aircrafts. Therefore they are called 'holy six'.

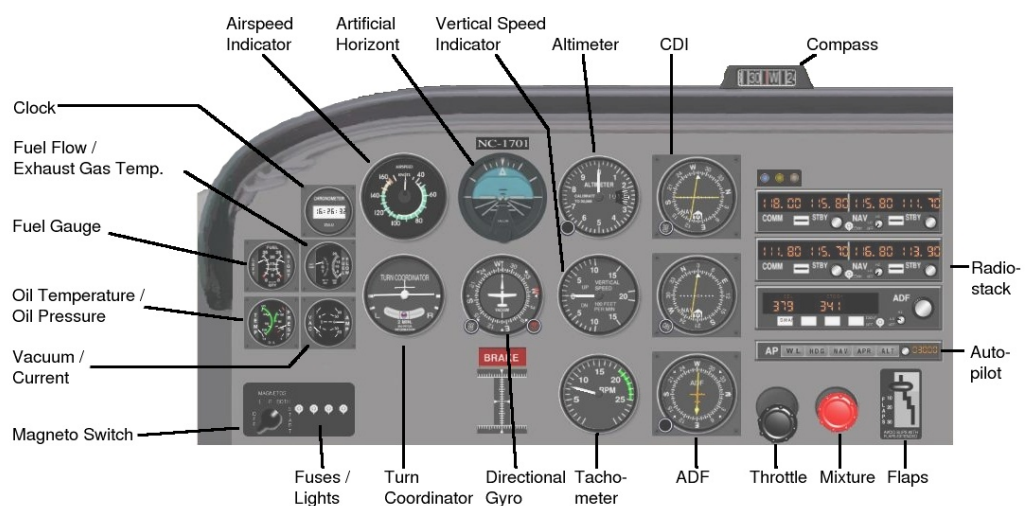


Fig.: Cockpit Overview

3.2 Starting the Engine

³ As per default, the master switch is on. Set the parking brake (B-key) to assure, that the plane does not start moving when you start the engine. Please check again the amount of fuel displayed on the gauges and compare the figure with the nominal value of fuel in the tanks.

Set the magnetos for the engine to BOTH ({-key). For the magneto-switch there are several positions OFF, R, L, BOTH, START. The engine of the C172 has two independent ignition systems. Each cylinder of the engine has two sparking plugs being triggered by one single magneto each. A magneto is comparable with the ignition system of a car, but it does not need any electricity. It uses a rotating permanent magnet. Therefore the ignition is absolutely independent of the electrical system of the plane and even in case of a total failure of the electric system, at least the engine will still be running.

For normal operation we will use both magnetos. So turn the switch to BOTH position by hitting {-Key 3 times.

Pull the mixture lever to 0% (away from the panel) and pull the throttle full back first and then push it approx 1.5cm to the front. Check that nobody is standing in the propeller area, then start the engine (SPACE-Key). Instantly push the mixture level completely to the front. Now the engine should be running. Please check the oil pressure. If it does not start to increase within 15 seconds, turn off the engine again by pulling the mixture to 0%.

The vacuum pumps should start and cause the artificial horizon to rotate a little bit, before it finds the straight position.

Switch on all necessary lights. TAX stands for taxiing lights, that will be used while taxiing, LNG stands for landing light, that will be used later on for the start, NAV for navigational lights (green light at the end of the right wing, red light at the end of the left wing and a white light at the tail unit), BCN for beacon (flashing red light on top of the tail unit) and STR for strobe. PTR stands for Pitot heating and is of no concern by now. So use the buttons TAX, NAV, BCN and STR right of the yoke.

3.3 Taxiing

For controlling the plane it's most realistic and comfortable to use a yoke (joystick) and pedals, but also keys may be used. To control the plane on ground only pedals will be needed. To make a right turn push the right pedal(Num -,key), for turning left push the left pedal(Num 0-key). Often novices make the mistake of turning the yoke in order to turn left or right. The speed may be controlled by the throttle settings (Num 3/9-key)or by using the brakes(b-key).

³At the moment only really necessary functions to start and control most of the *FlightGear*-Airplanes are programmed. So don't compare the instructions given here with real procedures. This manual will be updated as soon as the functionality is coded.

Before taxiing, please check for people or other planes. Look to the right (Shift-Num6) and to the left (Shift-Num4). Then release the parking brake (B-key) and push the throttle lever a little bit to aprox. 800rpm until plane starts to move. The speed of the plane will vary accoring to the ground surface. Here we have a solid concrete surface so only a little throttle setting is needed to let the plane move. But especially smaller airports often have gras run- and taxiways. In this case You have to adjust the power setting accordingly.

After a short distance You will enter the taxiway. The taxiway is the one with the yellow lines, runways have white markings. When passing the centre line make a left turn on the taxiway. Now You can increase the power setting a little bit. Usually You will taxi in a C172 with aprox. 900-1000 rpm. That's approximately the speed of a jogging person.

First try to keep the plane alined with the centre line. After a certain while you may also try some soft left and right curves or try to use the brakes.

You may also try to do some differential braking. The left and right wheels have independent brakes. By using only the brakes of one side, you may also turn the plane. Try to turn left by using only the left pedal brake ('-key) or the right brake by using the right pedal(.-key).

When You see the end of the taxiway pull the throttle lever completely out. At the end of the taxiway reduce the speed a little bit and turn right and stop in front of the solid white line. Set the parking brake.

3.4 Pre-Flight Checks

Before we will enter the runway, we have to do some further pre-flight checks. Each aircraft has its own described in the POH. We will start with a very basic one, that is caeld CIGARS due to mnemonic reasons.

3.4.1 CIGARS

Controls

This is to check if all controls are free and operate without any problems. Please change to outside view [v-key] and adjust the viewing angle [Shift-Numkeys] to see all controls.

First move the yoke to the front, than move it to the front left position, than back left position, back right position and finally front right position. The last step is to move the pedals from far right to far left position. You should be able to see the movements of the controls in the outside view.

Instruments

Check if all instruments are working and are displaying the expected values. Check especially the engine gauges for pressure and temperature. Now check the flight

instruments: Is the airspeed indicator at zero? The artificial horizon should show no significant attitude. Does the altimeter show the correct altitude for the airport? The turn coordinator should be in horizontal position. Does the directional gyro show the same direction as the conventional compass?

Gas

Check the fuel gauges for left and right fuel tank. Does the display show the same amount as you would expect to be in the tanks?

Attitude

Check the trim for the plane. In this special case, you do not have to check it, because we know, that it is set correct. We will see later, what trimming is and what influence a wrong setting will have to your plane.

Run-Up

As mentioned above the C-172 has two independent working magneto-systems. To check this, we will use the following procedure:

- Use the brakes (b-key) or set the parking brake [Shift-b].
- Increase throttle until the tachometer shows 1800 rpm.
- Turn the magneto switch to the R-position. You just switched off one of two magnetos. The engine should still be running, but with less power. Check the tachometer. It should only change about 50 to 100 rpm.
- Turn the magneto switch back to BOTH-position. Now the tachometer should return to 1800rpm.
- Turn the magneto switch to the L-position. Now you switched off the right magnetos. Again the tachometer should only change about 50-100 rpm.
- Turn the magneto switch back to BOTH-position

Check the vacuum gauge. It should be in the green area. All control and warning lights should be off now.

Safety

Check your seat belts, close all doors and check all luggage for a safe position.

Before we enter the runway look to the left and right for any approaching or departing aircrafts. If the runway is free increase the throttle a little bit and release the brakes (in this case we assume to have a clearance by the tower). Make a right turn and align the plane to the center line.

3.5 Take off

Often, when people have trouble controlling a plane in a PC simulator, it's because they're fixating on the panel and chasing the gauges. That's the wrong way to fly; here's the right way:

LOOK OUT THE WINDOW

These pictures show how you can fly smoothly by concentrating on where the horizon hits the nose of the plane; in other words, by paying attention to the plane's attitude. Your actual visual references for the horizon may change if you use a different pilot viewpoint or a different 3D model, but your first step should always be to learn the attitudes that work for the plane you're flying and then stick with them, cross-checking the airspeed indicator and altimeter no more often than you would check your rearview mirror in a car.

The run-up and pre-takeoff checks are finished and tower has cleared us onto the runway. The plane's not moving yet, so all three wheels are solidly on the ground. Look closely at the vertical distance between the top of the white cowling and the horizon. Right now, the horizon is between a third and a half way up the windshield, just like it will be during level cruise on the downwind leg and during final approach with the flaps down.

Now advance the throttle to full. The plane starts moving down the runway.

You will immediately notice the plane turning slightly to the left. No, this is not a mistake in the code. It is due to a combination of aerodynamic and physical effects. Often this effect is called the torque-effect. This is not completely true, although the propeller is causing a certain torque to the plane. The real reason for the sliding is the air that is moved by the propeller. The air is not pushed horizontally to the back, but more in a clockwise rotating spiral form (from behind the plane). At some point in the spiral the air is pushed against the left side of the tail-unit, causing the plane to rotate slightly to the left. To compensate this use the left pedal (Num 0-key). Try to keep the plane aligned to the center line.

The increasing speed causes the nose to lift slightly on its own, but the horizon is still between a half and a third of the way up the windshield.

As the speed increases, pull back just a little to take some weight off the nose-wheel. At 55kt, the nose wheel has started to lift a little off the runway: you can tell, because the horizon is now touching the bottom of the windshield. Now you are almost in the climb attitude.



Fig.: Raising the nose to the horizon

At 65kt, the other two wheels leave the runway and the plane is flying. Note that you do not have to yank it off by pulling the yoke way back: raising the nose only a tiny sliver above the horizon and holding it there is sufficient to get the plane into the air. Note where the horizon strikes the sides of the cowling, just above the top of the panel.



Fig.: Cockpit view at Lift off

3.6 Climbing

After the lift off, the plane keeps speeding up: in ground effect , there is no more friction from the tires but drag is very low. We want to climb at 70 kt, therefore we have to raise the nose a sliver higher to keep the airspeed down. Now, at 100 ft AGL, the plane is in the climb attitude: all of the white cowling is now above the horizon, and the horizon hits the sides at very top of the panel itself. As long

as you hold the horizon at this point, the plane will keep climbing smoothly at 70 kt.



Fig.: Cockpit view while climbing

Try to keep the plane in this situation - the wings horizontal and the nose a little bit up to gain more height. If the plane starts to roll and turn, move the yoke a little bit to the left or right. At the moment we do not care about our direction and luckily there are no other planes in your computer. If the nose starts to raise or fall correct the angle of attack by moving the yoke a little bit to the front. We will climb to 3.000ft. This will take some time. Check the altitude on the altimeter. But remember to look out of the window to control the roll angle of the plane.

While the plane is still climbing we will now use the autopilot to make the next lesson a little bit easier. First activate the autopilot's heading option [CTRL-H-key]. Now the autopilot controls the direction the plane is flying to. This autopilot's mode does know two different targets: waypoint or current heading. We have no waypoint to fly to, therefore toggle the target to the current heading [F6-key]. Now the autopilot controls the ailerons to hold the current heading. Details on the autopilot will be discussed in 4.1, 12.4.1 and you may only control the elevators.

3.7 Straight

3.8 Some Curves

First turns with and without rudder

3.9 Back Home

Finding the airport

3.10 Landing

speed, height, downwind, crosswind, final, landing

3.11 Black Boxes

instant replay and flight analysis (do we have one?)

Chapter 4

Basic Maneuvers

4.1 Autopilot I

After the first hours in the cockpit of the C172 it became obvious, that sometimes a pilot's job might be very stressful. Therefore some really smart people invented the autopilot.

Today there is a wide range of systems available. The simplest systems like in our C172 only controls the rotation around the longitudinal axis. These systems are called 'One-Axis-Systems. More complex ones are called 'Three-Axis-Systems'. They are able to do a complete flight from take-off to the final touch-down. It might be a little disappointing, but most of today's commercial flights are flown by autopilots only.

Let's have a look to the Introduction to ap, setting heading

4.2 Straight

4.2.1 Trim

How does it work? Why is it needed?

4.3 Curves

180deg turns, turns while climbing or descending, with flaps and gear

4.4 Stall

4.4.1 Angle of Attack

Normal stall, stall at low speed, stall in turns, flying with minimum speed

4.4.2 Flaps

4.5 Spin

How to spin and to to escape spin

4.6 Slipping

How to slip and why

Chapter 5

VFR Flying

5.1 Basics of VFR

What is VFR, what is IFR

5.1.1 Air Space

Differences in airspace

5.1.2 VFR Conditions

Am I allowed to fly?

5.2 Flight Planning

How to set up an flight plan, why, alternative airport

5.3 Navigation

Using maps, checkpoints, minimum en route height

5.3.1 Compass

Magnetic heading, true heading

5.3.2 Speed

True speed, IAS

5.3.3 Heading

Side winds, drift

5.4 Flying

From start to landing

5.4.1 Emergency Routines

What do I do if I lost my way?

Part II

Navigation and more

Chapter 6

Navigation I

6.1 Non Directional Beacon - NDB

6.1.1 What's a NDB?

How does it work, frequencies

6.1.2 Instrumentation

Which instrument do I need to find NDBs? How does it work

6.1.3 Position

Position relative to a NDB

6.1.4 Tracking

How do I keep track on a NDB

6.1.5 Intersecting

Change to an other course

6.2 Transponder

What is a transponder? Instruments and how to use

6.2.1 Transponder Codes

7700 ;-)

6.2.2 Transponder Modes

STBY, ON, ALT, IDENT

Chapter 7

More Power — Twin Engine

7.1 Basics of Twin Engines

Physics with two engines, counter rotating props, turboprop?

7.2 Cessna 310

Introduction of the airplane, retractable gear

7.3 Starting Two Engines

procedure for (cross) starting

7.4 Taxiing

Use the engines to make turns on the ground, CIGAR-TIP

7.5 Flying

Power setting, getting used to the aircraft

7.6 Autopilot II

Explanation of additional functions like height and climb control

7.7 Emergency — Engine Failure

7.7.1 ... while flying

Procedures to reach the next airport (Fly the aircraft!!!)

7.7.2 ... while starting

How to take off safely

Chapter 8

Navigation II

8.1 VHF Omnidirectional Range — VOR

8.2 What's a VOR?

8.2.1 Types of VORs

8.2.2 DME

8.3 Instrumentation

8.3.1 Position

8.3.2 Tracking

8.3.3 Intersecting

Chapter 9

Jet Engines

9.1 How do Jets work?

9.2 LearJet 24

Introduction to the airplane

9.3 Starting the Engine

Procedure for starting the engine

9.4 Take Off

Power setting, take off speeds (V1 VR V2)

9.5 Flying

Mach-speed, descent

9.6 Landing

Setting for landing, speed (VREF)

Chapter 10

B747 - The real big One!

Introduction to the airplane

10.1 Cockpit

Where to find everything

10.2 Starting the Engine

Procedure for starting the engines, pre-flight checks

10.3 FMC

Capabilities of FMC (do we have one?), how to use

10.4 Takeoff

Speeds, rotation, flaps

10.5 Landing

Speed, flaps, air brakes, reverse thrust

Chapter 11

Is there anybody out there? - ATC

11.1 Who is there?

11.1.1 FSS

What's FSS?

11.1.2 ATIS

What's ATIS

11.1.3 Ground

What's...

11.1.4 Tower

What's...

11.1.5 Departure and Approach

What's...

11.1.6 Center

What's...

11.2 Procedures

11.2.1 VFR

Who do I talk to? When and why

Multicom

How does it work without any responsible person?

Circuit

Traffic patterns

11.2.2 IFR

Who do I talk to? When and why

11.3 Multi Player Mode

How to use multi player mode in *FlightGear*

11.3.1 Log In

log on to servers

11.3.2 Communication

speaking to other pilots

Chapter 12

Navigation III

12.1 Instrument Landing System — ILS

How does it work?

12.2 Maps and Charts

SIDs, STARs IAP-Charts

12.3 Instrumentation

How to set nav and read HSI

12.4 Landing

Establish ILS

12.4.1 Autopilot III

Approach mode and automatic landing

12.4.2 Manually

How to keep track on ILS in foggy conditions

Chapter 13

Weather

Why do we have weather

13.1 Climate

low and high pressure areas

13.2 Wind

strength of winds, layers

13.3 Clouds

Types of clouds, storms, lightning

13.4 Ice

Icing conditions, anti-icing systems

13.5 Flight Planing

How to get information concerning the weather, how does this influence my flight

13.6 weather radar

How to read it?

Chapter 14

Navigation IV

14.1 Global Positioning System - GPS

14.2 What's GPS?

How does GPS work? Satellites, resolution

14.3 Instrumentation

How to use it? Navigation using GPS, GPS approaches

Chapter 15

War Games

15.1 Tactics

How do I fly in a combat situation, wing man's work

15.2 Harrier

Introduction to the airplane

15.2.1 Cockpit

Where to find everything

15.2.2 Weapons

Systems, targeting, shooting

Chapter 16

Helicopter

16.1 Basics of Helicopter Flying

How to fly a Heli

16.1.1 Physics of Helicopters

16.1.2 Controls

16.2 Flying

16.2.1 Starting the Engine

16.2.2 Take-Off

16.2.3 Horizontal Moves

16.2.4 Landing

Chapter 17

Flying???

17.1 Balloon

How to fly a balloon

17.2 The Steps of Wilburgh and Arthur

History of the wright brothers. How to fly their bird.

17.3 UFO — The Future?

Going to Mars

Part III
Appendix

Appendix A

Aviation History

b.c.	According to Greek mythology Daidalos and Ikarus were the first men in history to fly. They made wings from feathers to escape their prison on the Greek island Crete. Unfortunately they flew too high and the sun melted the wax they used.
aprox. 1500	Leonardo da Vinci (1452-1519) made first sketches of planes and helicopters.
aprox. 1782-83	The French brothers Jacques Etienne and Joseph Michel de Montgolfier build the first balloons and reached in 1783 a height of 1800m with an unmanned balloon.
aprox. 1890	Otto Lilienthal made first hang gliding flights of some 100m after studies of birds, bird flight and aerodynamics. He died in a plane crash in 1896.
1903	Based on the work of Lilienthal, Orville and Wilbur Wright made the first motor flight in history.
1911	After 11 years of development the first commercial passenger transportation started using Zeppelin aircraft.
1924	First trans atlantic flight of a Zeppelin.
1927	First single transatlantic of Charles Lindbergh from New York to Paris in 33½ hours. His plane was called 'Spirit of St.Louis'.
1937	The crash of the Zeppelin 'Hindenburg' in Lakehurst ended a 13 year trans atlantic passenger service between Europe and Nord or South america.
1939	The Henkel He178 was the first plane equipped with a jet engine.
1942	The first rockets were developed in Germany.
1947	The Bell X-1 was the first plane to fly at supersonic speed. The pilot was Chuck Yeager.
1956	Using the Tupolev TU-104 the first jet passenger service started between Moskow and Prague.
1957	The first satellite called 'Sputnik' was launched in the Soviet Union.
1961	Juri Alexejewitsch Gagarin was the first man to go round the world in space.
1968	The Tupolev TU-144 was the first supersonic passenger plane.
1969	N. Armstrong and E. Aldwin were the first men on the moon. M. Collins was the third man of the Apollo 11 mision, he had to stay in the space craft 'Columbia' surrounding the moon.

- 1976 Air France and British Airways start a regular supersonic passenger service from Paris and London to New York using the 'Concorde'.
- 1994 Development of *FlightGear* started.

Appendix B

The Aircraft

Technical description of the airplanes available in *FlightGear*. All information listed below is only for use within *FlightGear*. Do not use in real flight situations.

B.1 Cessna 172R - Skyhawk

B.1.1 General

The Skyhawk aircraft is an all-metal, single piston, high-wing monoplane with a four-person seating capacity including a crew of one or two. Suitable allowance for luggage is provided.

The model 172R is certified to the requirements of U.S. FAA Federal Aviation Regulation Part 23 including day, night, VFR and IFR.¹

B.1.2 Technical Information

Approximate Dimensions¹

	English	Metric
Baggage Door		
Height (front)	22"	0.56 m
Height (rear)	21"	0.53 m
Width	15.3"	0.39 m
Cabin		
Height (max)	48"	1.22 m
Length (firewall to aft baggage area)	142"	3.61 m
Width	39.5"	1.00 m
Cabin Door		
Height (front)	40.5"	1.03 m

¹Information of this chapter is taken from Skyhawk web page (18.11.2002), see App. J

Height (rear)	39"	0.99 m
Width (top)	32.5"	0.83 m
Width (bottom)	37"	0.94 m
Overall Height (max)	8'11"	2.72 m
Overall Length	27'2"	8.28 m
Wing		
Span (overall)	36'1"	11.0 m
Area	174 sq ft	16.2 sq m

Design Weights and Capacities¹

	English	Metric
Baggage Allowance	120 lbs	54 kg
Fuel Capacity		
Total capacity	56.0 gal	212 liters
Total usable	53.0 gal	200.6 liters
Total capacity each tank	28.0 gal	106 liters
Landing Weight		
	English	Metric
kg		
Utility category	2,100 lbs	953 kg
Maximum Useful Load		
Normal category	837 lbs	380 kg
Utility category	487 lbs	221 kg
Oil Capacity	8 qts	7.6 liters
Ramp Weight		
Normal Category	2,457 lbs	1,114 kg
Utility Category	2,107 lbs	956 kg
Standard Empty Weight	1,620 lbs	743 kg
Take-off Weight		
Normal Category	2,450 lbs	1,111 kg

¹Information of this chapter is taken from Skyhawk web page (18.11.2002), see App. J

Utility Category	2,100 lbs	953 kg
------------------	-----------	--------

Further Information²

Velocities

max. Velocity at MSL		123 knots
Cruise, 75% power at 8.000ft		120 knots
Cruise: lean mixture, additional fuel for starting the engine, taxiing, take-off, climb and 45 min. reserve.		
75% power at 8.000 ft	range	440 NM (814,88 km)
40 gal (151,4 liters) fuel	time	3,8 hrs
max. range at 10.000 ft	range	520 NM (963,04 km)
40 gal (151,4 liters) fuel	time	5,6 hrs
Rate of climb	700 fpm	
Max. height	13.000ft	
Take-off		
Take-off distance	890 ft	
Total distance (50 ft obstacle)	1.625 ft	
Landing		
Landing distance	540 ft	
Total landing distance (50 ft obstacle)	1.280 ft	

Velocities³

	KCAS	KIAS
V_{NE}	152	158
V_{NO}	123	127
V_A		
2.400 lbs (1.088,64 kg)	97	99
2.000 lbs (907,2 kg)	91	92
1.600 lbs (725,76 kg)	81	82
V_{NE}		
10°flaps	108	110
10°- 30°flaps	84	85

²for Cessna Skyhawk 172P[8]

³for Cessna Skyhawk 172P[8]

Instrument markings⁴

		KIAS	
airspeed indicator			
	white area		33 - 85
	green area		44 - 127
	yellow area		127 - 158
	red line		158
Instrument	red line (min.)	green area	red line (max.)
rpm indicator			
MSL	-	2,100 - 2,450 rpm	-
5,000 ft	-	2,100 - 2,575 rpm	2,700 rpm
10,000 ft	-	2,100 - 2,700 rpm	-
oil temperature	-	100° - 245°F	245°F
oil pressure	25 psi	60 - 90 psi	115 psi

B.1.3 Checklists**PREFLIGHT INSPECTION****(1) Cabin**

1. Pilot's Operating Handbook – AVAILABLE IN THE AIRPLANE.
2. Control Wheel Lock – REMOVE.
3. Ignition Switch – OFF.
4. Avionics Power Switch – OFF.
5. Master Switch – ON.
6. Fuel Quantity Indicators – CHECK QUANTITY.
7. Avionics Cooling Fan – CHECK AUDIBLY FOR OPERATION.
8. Master Switch – OFF.
9. Static Pressure Alternate Source Valve (if installed) – OFF.
10. Baggage Door – CHECK, lock with key if child's seat is to be occupied.

(2) Empennage

1. Rudder Gust Lock – REMOVE.
2. Tail Tie-Down – DISCONNECT.
3. Control Surfaces – CHECK freedom of movement and security.

⁴for Cessna Skyhawk 172P[8]

(3) Right Wing Trailing Edge

1. Aileron – CHECK freedom of movement and security.

(4) Right Wing

1. Wing Tie-Down – DISCONNECT.
2. Main Wheel tire – CHECK for proper inflation.
3. Before the first flight of the day and after each refueling, use sampler cup and drain small quantity of fuel from fuel tank sump quick-drain valve to check for water, sediment, and proper fuel grade.
4. Fuel Quantity – CHECK VISUALLY for desired level.
5. Fuel Filler Cap – SECURE.

(5) Nose

1. Engine Oil Level – CHECK, do not operate with less than five quarts. Fill to seven quarts for extended flight.
2. Before first flight of the day, and after each refueling, pull out strainer drain knob for about four seconds to clear fuel strainer of possible water and sediment. Check strainer drain closed. If water is observed, the fuel system may contain additional water, and further draining of the system at the strainer, fuel tank sumps, and fuel selector valve drain plug will be necessary.
3. Propeller and Spinner – CHECK for nicks and security.
4. Landing Light(s) – CHECK for condition and cleanliness.
5. Carburetor Air Filter – CHECK for restrictions by dust or other foreign matter.
6. Nose Wheel Strut and Tire – CHECK for proper inflation.
7. Nose Tie-Down – DISCONNECT.
8. Static Source Opening (left side of fuselage) – CHECK for stoppage.

(6) Left Wing

1. Main Wheel Tire – CHECK for proper inflation.
2. Before first flight of the day and after each refueling, use sampler cup and drain small quantity of fuel from fuel tank sump quick-drain valve to check for water, sediment, and proper fuel grade.
3. Fuel Quantity – CHECK VISUALLY for desired level.
4. Fuel Filler Cap – SECURE.

(7) Left Wing Leading Edge

1. Pitot Tube Cover – REMOVE and check opening for stoppage.
2. Fuel Tank Vent Opening – CHECK for stoppage.
3. Stall Warning Opening – CHECK for stoppage. To check the system, place a clean handkerchief over the vent opening and apply suction: a sound from the warning horn will confirm system operation.
4. Wing Tie-Down – DISCONNECT.

(8) Left Wing Trailing Edge

1. Aileron – CHECK for freedom of movement and security.

BEFORE STARTING ENGINE

1. Preflight Inspection – COMPLETE.
2. Seats, Seat Belts, Shoulder Harnesses – ADJUST and LOCK.
3. Fuel Selector Value – BOTH.
4. Avionics Power Switch, Autopilot (if installed), Electrical Equipment – OFF.
5. Brakes – TEST and SET.
6. Circuit Breakers – CHECK IN.

STARTING ENGINE

1. Mixture – RICH.
2. Carburetor Heat – COLD.
3. Master Switch – ON.
4. Prime – AS REQUIRED (2 to 6 strokes; none if engine is warm).
5. Throttle – OPEN 1/8 INCH.
6. Propeller Area – CLEAR.
7. Ignition Switch – START (release when engine starts).
8. Oil Pressure – CHECK.
9. Flashing Beacon and Navigation Lights – ON as required.
10. Avionics Power Switch – ON.
11. Radios – ON.

BEFORE TAKEOFF

1. Parking Brake – SET.
2. Cabin Doors and Window(s) – CLOSED and LOCKED.
3. Flight Controls – FREE and CORRECT.
4. Flight Instruments – SET.
5. Fuel Selector Value – BOTH.
6. Mixture – RICH (below 3000 feet).
7. Elevator Trim and Rudder Trim (if installed) – TAKEOFF.
8. Throttle – 1700 RPM.
 - (a) Magnetos – CHECK (RPM drop should not exceed 125 RPM on either mag-neto or 50 RPM differential between magnetos).
 - (b) Carburetor Heat – CHECK (for RPM drop).
 - (c) Engine Instruments and Ammeter – CHECK.
 - (d) Suction Gage – CHECK.

9. Throttle – 1000 RPM or LESS.
10. Radios – SET.
11. Autopilot (if installed) – OFF.
12. Air Conditioner (if installed) – OFF.
13. Strobe Lights – AS DESIRED.
14. Throttle Friction Lock – ADJUST.
15. Brakes – RELEASE.

TAKEOFF

Normal Takeoff

1. Wing Flaps – 0 deg - 10 deg.
2. Carburetor Heat – COLD.
3. Throttle – FULL OPEN.
4. Elevator Control – LIFT NOSE WHEEL (at 55 KIAS).
5. Climb Speed – 70-80 KIAS.

Short Field Takeoff

1. Wing Flaps – 10 deg.
2. Carburetor Heat – COLD.
3. Brakes – APPLY.
4. Throttle – FULL OPEN.
5. Mixture – RICH (above 3000 feet, LEAN to obtain maximum RPM).
6. Brakes – RELEASE.
7. Elevator Control – SLIGHTLY TAIL LOW.
8. Climb Speed – 56 KIAS (until all obstacles are cleared).

ENROUTE CLIMB

1. Airspeed – 70-85 KIAS.
2. Throttle – FULL OPEN.
3. Mixture – RICH (above 3000 feet, LEAN to obtain maximum RPM).

CRUISE

1. Power – 2100-2700 RPM (no more than 75
2. Elevator and Rudder Trim (if installed) – ADJUST.
3. Mixture – LEAN.

DESCENT

1. Fuel Selector Value – BOTH.
2. Mixture – ADJUST for smooth operation (full rich for idle power).
3. Power – AS DESIRED.
4. Carburetor Heat – FULL HEAT AS REQUIRED (to prevent carburetor icing).

BEFORE LANDING

1. Seats, Seat Belts, and Shoulder Harnesses – SECURE.
2. Fuel Selector Value – BOTH.
3. Mixture – RICH.
4. Carburetor Heat – ON (apply full heat before reducing power).
5. Autopilot (if installed) – OFF.
6. Air Conditioner (if installed) – OFF.

LANDING**Normal Landing**

1. Airspeed – 65-75 KIAS (flaps UP).
2. Wing Flaps – AS DESIRED (0 deg - 10 deg below 110 KIAS, 10 deg - 30 deg below 85 KIAS).
3. Airspeed – 60-70 KIAS (flaps DOWN).
4. Touchdown – MAIN WHEELS FIRST.
5. Landing Roll – LOWER NOSE WHEEL GENTLY.
6. Braking – MINIMUM REQUIRED.

Short Field Landing

1. Airspeed – 65-75 KIAS (flaps UP).
2. Wing Flaps – FULL DOWN (30 deg).
3. Airspeed – 61 KIAS (until flare).
4. Power – REDUCE to idle after clearing obstacle.
5. Touchdown – MAIN WHEELS FIRST.
6. Brakes – APPLY HEAVILY.
7. Wing Flaps – RETRACT.

BALKED LANDING

1. Throttle – FULL OPEN.
2. Carburetor Heat – COLD.
3. Wing Flaps – 20 deg (immediately).
4. Climb Speed – 55 KIAS.
5. Wing Flaps – 10 deg (until obstacles are cleared).
RETRACT (after reaching a safe altitude and 60 KIAS)

AFTER LANDING

1. Wing Flaps – UP.
2. Carburetor Heat – COLD.

SECURING AIRPLANE

1. Parking Brake – SET.
2. Avionics Power Switch, Electrical Equipment, Autopilot if installed) – OFF.
3. Mixture – IDLE CUT-OFF (pulled full out).
4. Ignition Switch – OFF.
5. Master Switch – OFF.
6. Control Lock – INSTALL.

B.2 Cessna 182

B.3 Cessna 310

B.4 Beech 99

B.5 Harrier

B.6 DC 3

B.7 Boeing 747

Appendix C

Property Manager

C.1 xxx

C.2 yyyy

Appendix D

Abbreviations

A

A/P	Auto Pilot
A/T	Auo Throttle, A/P Subsystem that controls the throttle
AC	Aircraft
AD	Airworthiness Directive
ADF	Automatic Direction Finder
ADIZ	Air Defense Identification Zone
A/FD	Airport/Facility Directory
AFSS	Automated Flight Service Station
AGL	Above Ground Level
AI	Attitude Indicator
AIM	Airmen's Information Manual
AIRMET	Airmen's Meteorological Information
ALS	Approach Light System
ALT	Altitude; Altimeter
Apt Elev	Airport Elevation (MSL)
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASI	Airspeed Indicator
ASOS	Automated Surface Observing System
ATA	Airport Traffic Area
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
ATCT	Air Traffic Control Tower
ATD	Actual Time of Departure
ATIS	Automatic Terminal Information System
ATP	Airline Transport Pilot
AVGAS	Aviation Gasoline
AWOS	Automated Weather Observing System

B

BC	Back Course
BRITE	Bright Radar Indicator Tower Equipment

C

C	Centigrade
CAS	Calibrated Airspeed
CAT	Clear Air Turbulence
CD	Clearance Delivery
CDI	Course Deviation Indicator
CFI	Certified Flight Instructor
CG	Center of Gravity
CH	Compass Heading
CRS	Course
CT	Control Tower
CTAF	Common Traffic Advisory Frequency

D

DA	Density Altitude
DF	Direction Finder
DG	Directional Gyro
DH	Decision Height
DME	Distance Measuring Equipment
DR	Dead Reckoning
DUAT	Direct User Access Terminal

E

EFAS	En Route Flight Advisory Service
EGT	Exhaust Gas Temperature
EICAS	Engine Indicator and Crew Alerting System
ELEV	Elevation
ELT	Emergency Locator Transmitter
ETA	Estimated Time of Arrival

ETD Estimated Time of Departure
ETE Estimated Time En Route

F

F Fahrenheit
FA Area Forecast
FAA Federal Aviation Administration
FAF Final Approach Fix
FAR Federal Aviation Regulation
FBO Fixed Base Operator
FD Flight Director
FL Flight Level
FPM Feet Per Minute
FSS Flight Service Station
ft feet

G

G/S Glide Slope
g Gravity
GD Ground Control
GMT Greenwich Mean Time
GND Ground
GOES Geostationary Operational Environmental Satellite
GPS Global Positioning System
GS Ground Speed; Glide Slope

H

HAA Height Above Airport
HDG Heading
HF High Frequency
Hg Mercury (barometric measure)
HGT Height
HI Heading Indicator
HIRL High Intensity Runway Lights
HSI Horizontal Situation Indicator
Hz Hertz (cycles per second)

I

IAF	Initial Approach Fix
IAP	Instrument Approach Plate
IAS	Indicated Airspeed
IATA	Airport Designator, used on flight tickets
ICAO	International Civil Aviation Organization
	Airport Designator, used for Navigation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IM	Inner Marker
IMC	Instrument Meteorological Conditions
ISA	International/ICAO Standard Atmosphere

K

KCAS	Knots Calibrated Airspeed
kHz	Kilohertz
km	Kilometer
kt	Knot
KTAS	Knots True Airspeed

L

LDA	Localizer Directional Aid
LIFR	Low Instrument Flight Rules
LIRL	Low Intensity Runway Lights
LL	Low Lead
LNAV	Lateral Navigation
LOC	Localizer
LOC-A	Type of Approach Plate
LORAN	Low Range Navigation
LW	Landing Weight

M

MALSR	Medium Intensity Approach Light System with Runway Alignment
--------------	--

MAP	Miised Approach Point
MAYDAY	International Distress Radio Signal
MC	Magnetic Compass; Magnetic Course
MDA	Minimum Descent Altitude
MEA	Mean Enroute Altitude
MEF	Maximum Elevation Figures
METAR	Meteorological Reports-Aviation Routine
MH	Magnetic Heading
MHz	Megahertz
MIRL	Medium Intensity Runway Lights
MLS	Microwave Landing System
MM	Middle Marker
MOA	Military Operations Area
MOCA	Minimum Obstruction Clearance Altitude
MSA	Minimum Sector Altitude
MSL	Mean Sea Level
MTOW	Maximum Take-off Weight
MTR	Military Training Route
Multicom	self-announcing radio frequency
MVFR	Marginal Visual Flight Rules

N

Navaid	Navigational Aid
ND	Navigation Display
NDB	Non-Directional Beacon
NM	Nautical Miles
NOS	National Ocean Service
NOTAM	Notice To Airmen
NTSB	National Transportation Safety Board
NWS	National Weather Service

O

OAT	Outside Air Temperature
OBS	Omni Bearing Selector
OM	Outer Marker
OVC	Overcast

P

PA	Pressure Altitude
PAPI	Precision Approach Path Indicator
PD	Primary Display
PF	Pilot Flying
PIREP	Pilot Weather Report
PNF	Pilot Non-Flying
POH	Purchase Owners Handbook
PVASI	Pulsating Visual Approach Slope Indicator

Q

QFE	Air Pressure at Airport Height
QNH	Air Pressure at Airport Height, calibrated to MSL
QNE	Standard Air Pressure (1.013 hPA)

R

RAIL	Runway Alignment Indicator
RAS	Rectified Airspeed
RAT	Ram Air Temperature
RBI	Relative Bearing Selector
RCLS	Runway Centerline Lighting System
RCO	Remote Communications Outlet
REIL	Runway End Identifier Lights
RMI	Radio Magnetic Indicator
RNAV	Area Navigation
RPM	Revolutions Per Minute
RTO	Rejected Takeoff
RVR	Runway Visibility Range
RWY	Runway

S

SA	Surface Observations
SAT	Static Air Temperature
SCTD	Scattered
SDF	Simplified Directional Facility

SID	Standard Instrument Departure
SIGMET	Significant Meteorological Advisory Alert
SM	Statute Mile
SPECI	Special Forecast
Squawk	activate transponder code
STAR	Standard Terminal Arrival
SUA	Special Use Airspace
SVFR	Special Visual Flight Rules

T

TAC	Terminal Area Chart
TACAN	Tactical Air Navigation
TAF	Terminal Area Forecast
TAS	True Airspeed
TAT	Total Air Temperature
TC	True Course
TCA	Terminal Control Area
TDZE	Touch Down Zone Elevation
TDZL	Touchdown Zone Lights
TH	True Heading
TRACON	Terminal Radar Service Approach Control
TRSA	Terminal Radar Service Area
T-VASI	T-form Visual Approach Slope Indicator
TWEB	Transcribed Weather Broadcast

U

UHF	Ultra High Frequency
Unicom	aeronautical advisory radio communications unit
UTC	Universal Time Coordinated or Greenwich Mean Time

V

V_A	Maneuvering Speed
V_{FE}	Maximum Flap Extended Speed
V_{LE}	Maximum Landing Gear Extended Speed
V_{LO}	Maximum Landing Gear Operating Speed
V_{min}	Minimum Speed

V_{NE}	Never Exceed Speed
V_{NO}	Maximum Structural Cruising Speed, Maximal Normal Operating Speed
V_S	Stalling Speed
V_{S0}	Stalling Speed with extended Flaps
V_{S1}	Stalling Speed with retracted Flaps
V_X	Best Angle of Climb Speed
V_Y	Best Rate of Climb Speed
VAR	Variation
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	VHF Omnidirectional Range
VOR/DME	VOR + Distance Measuring Equipment
VORTAC	VOR + TACAN
VFR	Visual Flight Rules
VNAV	Vertical Navigation, A/P
VSI	Vertical Speed Indicator

W

WAC	World Aeronautical Charts
WCA	Wind Correction Angle
WSFO	Weather Service Forecast Office
WSO	Weather Service Office

Z

Zulu	Universal Time Coordinated (UTC); Greenwich Mean Time
-------------	---

Appendix E

Airport Lightning Systems

Explanation of different lighting systems at airports








Appendix F

Maps

F.1 Chart Symbols

Airports

	Hamburg	International Airport
	Lemwerder	Airport resp. Airfield IFR
	Buchel	Military aerodrome
	Hohenfels	Airfield (civil/military)
	Breitscheid	Airfield, alignment on the longest hardened runway
	Hettstadt	Airfield, alignment on the longest grass runway
		Airfield, closed
	Saffig	Heliport Civil resp. Military
		Heliport for ambulances

	Baldenau	Glider site aero tow resp. winch launching
	Berg	Ultra light flying
	Waldkirch	Hang glider site
	Calw	Parachute jumping site, low resp. high activities
	Attrach	Free balloon site
		Aerodrome beacon light
		
<u>123.000</u>	650m	The shorter of the available landing dist of the longest RWY
		Available frequency (underlined VDF available)
118.450 A/A		Air/Air Communications (France)

Radio Navigation Facilities



VOR

VHF omnidirectional radio range



VOR/DME

VHF omnidirectional radio range with distance measuring equipment



VORTAC

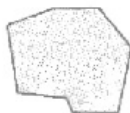
Co-located VOR and TACAN facilities



NDB

Co-located VOR and TACAN facilities

Build-up Areas



Bonn

City
(100 000 inhabitants and more)



Hof









Town
(more than 20 000 inhabitants and villages with less than 20 000 inhabitants)









Neuhaus

Village
(5 000 to 20 000 inhabitants and villages with less than 5 000 inhabitants in sparsely populated areas)

Roads

	Dual Highway
	Dual Highway under construction
	Primary road
	Secondary road
	Race track
	Dual highway entry
	Road bridge
	Road tunnel

Railways

	Railway (single track) with station
	Railway (multiple track) with station
	Railway (abandoned or under construction)
	Railway bridge
	Railway tunnel
	Aerial railway

Hydrography



Shore line



Tidal flats



River



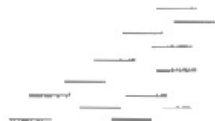
Canal



Abandoned canal or canal under construction



Lake



Swamp



Ferry



Dam



Barrage



Lock, ship hoist



Groyne, mole



Pier, submerged rock

Boundaries



Boundaries

Landmarks

Miscellaneous

Airspace Structure

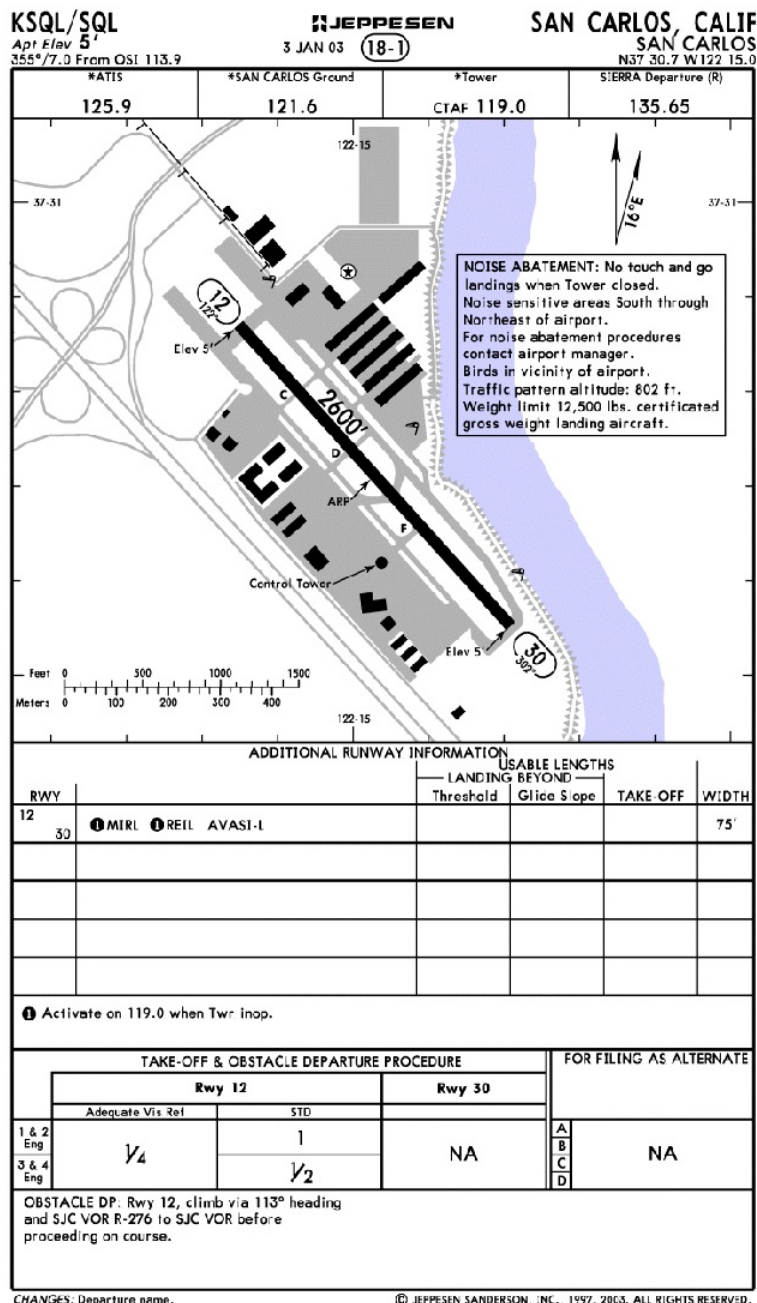
Airspace Restrictions

Transponder Setting

Appendix G

Charts

G.1 Airport Charts



G.2 Standard Instrument Departure (SID)

G.3 Instrument Approach Procedure Charts (IAP)

G.4 Standard (STAR]

Appendix H

Communications

Phonetic Alphabet

Alpha	Golf	Mike	Sierra	Yankee
Bravo	Hotel	November	Tango	Zulu
Charlie	India	Oscar	Uniform	
Delta	Juliett	Papa	Victor	
Echo	Kilo	Quebec	Whiskey	
Foxtrot	Lima	Romeo	X-ray	

Morse Alphabet

A .-	K -.-	U ..-	5
B -...	L -.-..	V ...-	6 -....
C -.-.	M --	W .--	7 -...-
D -..	N -.	X -.-.-	8 ---..
E .	O ---	Y -.----	9 ----.
F ..-.	P .--.	Z --..	0 -----
G --.	Q --.-	1 .----	. (dot) .-.-.-
H	R .-.	2 ..---	, (colon) --.-
I ..	S ...	3 ...--	/ -.-.-
J .---	T -	4-	? ..-..

Appendix I

Unit Systems

I.1 SI Units

I.2 British System

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Appendix J

Related Links

J.1 General Aviation

J.1.1 Aircraft

www.skyhawk.cessna.com

J.1.2 Maps Charts

www.myairplane.com/databases/approach/index.php

J.2 Flight Simulation

J.2.1 *FlightGear*

www.flightgear.org

Appendix K

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