Manuale di FlightGear

Michael Basler, Martin Spott,
Stuart Buchanan, Jon Berndt,
Bernhard Buckel, Cameron Moore,
Curt Olson, Dave Perry,
Michael Selig, Darrell Walisser,
e altri Traduzione a cura di Jacopo Mii

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Prefazione

FlightGear è un simulatore di volo gratuito sviluppato in modo cooperativo su internet da un gruppo appassionati di simulatori di volo e di programmazione. Il Manuale di FlightGear è destinato a dare ai principianti una guida per ottenere FlightGear installato e funzionante sul proprio computer, e il piacere di volare virtualmente da casa propria. Non è destinato a fornire una documentazione completa di tutte le caratteristiche e componenti aggiuntivi del simulatore, ma, invece, mira a far comprendere ad un nuovo utente ciò che esso ha di meglio da offrire.

Questa versione del manuale è stata scritta per FlightGear versione 3.2.0. Gli utenti che usano versioni precedenti di FlightGear potranno ancora trovare questo documento utile, ma alcune delle caratteristiche descritte potrebbero non essere presenti.

Questa guida è divisa in tre parti ed è strutturata come segue.

Parte I: Installazione

Capitolo 2, *Vuoi avere un simulatore di volo libero? Usa FlightGear!*: Fornisce la filosofia di base che c'è dietro al programma e descrive i requisiti di sistema

Capitolo 3, *Prima di volare: installazione di FlightGear*: Fornisce le istruzioni per installare il gioco e paesaggi/aerei

Parte II: Volare con FlightGear

Capitolo 4, *Inizio: come avviare il programma*: Descrive come avviare il programma. Comprende una panoramica sulle numerose opzioni della riga di comando e sui file di configurazione

Capitolo 5, *In volo: tutto su strumenti, tasti e menù*: Descrive come volare con *FlightGear*. Contiene l'elenco completo dei comandi da tastiera predefiniti, spiega le voci dei vari menù e descrive dettagliatamente il pannello degli strumenti e l'HUD. Inoltre dà dei consigli sull'utilizzo del mouse e delle sue funzioni.

Capitolo 6, *Caratteristiche*: Descrive alcune delle caratteristiche speciali che FlightGear offre per l'utente avanzato

Partie III : Tutorial

Capitolo 7, *Tutorial*: Fornisce informazioni sui molti tutorial disponibili per i nuovi utenti

Capitolo 8, *Le basi dei simulatori di volo*: Spiega le basi del volo attraverso molti esempi

Capitolo 9, *Tutorial: un volo nazionale*: Descrive un semplice volo nazionale ambientato nella zona di San Francisco che può essere eseguito con l'installazione di default

Capitolo 10, *Un volo nazionale IFR*: Descrive un volo nazionale facendo uso degli strumenti di bordo per volare con successo tra le nuvole seguendo le regole di un volo strumentale

Appendici

Appendice A, *Se qualcosa si rifiuta di funzionare*: Spiega come risolvere alcuni problemi comuni che potrebbero verificarsi durante l'utilizzo di FlightGear

Appendice B, *Riflessioni su FlightGear*: Contiene i crediti di chi ha sviluppato FlightGear e illustra cosa rimane da fare nel simulatore

1.1   Lecture condensée

Per coloro che non vogliono leggere questo manuale dall'inizio alla fine, si evidenziano le sezioni più importanti indispensabili per poter usare il simulatore:

1.2   Istruzioni per i più impazienti

Sappiamo che la maggior parte delle persone odiano leggere i manuali. Se si è sicuri che la scheda grafica del proprio computer supporti OpenGL (consultare la documentazione; ad esempio in generale le schede NVIDIA lo supportano) e si utilizza Windows, Mac OS-X o Linux, probabilmente si può ignorare almeno parte di questo manuale e usare i file d'installazione pre-compilati.

Questi, oltre alle istruzioni su come impostarli, possono essere trovati sul sito

http://www.flightgear.org/download/.

Se si usa Linux, è possibile che *FlightGear* sia già integrato nel pacchetto con la distribuzione. Dopo aver scaricato e installato i file binari, vedere il Capitolo 4 per i dettagli su come avviare il simulatore.

1.3   Ulteriori documentazioni

Sebbene questa guida introduttiva sia progettata per essere autosufficiente, si suggerisce di leggere le ulteriori documentazioni, in particolare in caso di problemi :

- Un pratico opuscolo riassuntivo è contenuto nel pacchetto di installazione all'indirizzo `/FlightGear/Docs` oppure al sito :

  http://www.flightgear.org/Docs/FGShortRef.pdf.

- É disponibile anche un **wiki** ufficiale di *FlightGear* all'indirizzo http://wiki.flightgear.org e un forum all'indirizzo http://forum.flightgear.org.

Parte I

Installation

Capitolo 2

Vuoi avere un simulatore di volo libero? Usa *FlightGear* !

2.1   Ancora un altro simulatore di volo?

Desideri pilotare un aereo da solo, ma non vuoi spendere denaro o non hai le capacità per farlo? Sei un vero pilota e stai cercando di migliorare le tue abilità , senza dover decollare realmente? Vuoi provare alcune manovre pericolose senza rischiare la vita? O vuoi solo divertirti con un gioco più serio, senza alcun pericolo? Se ad almeno una di queste domande la tua risposta è "Sì", vuol dire che i simulatori di volo per computer sono adatti per te.

Si può già avere una buona esperienza di volo con Microsoft Flight Simulator o con un qualsiasi altro dei molti simulatori di volo per pc disponibili in commercio, ma nonostante il basso prezzo di uno di questi (di solito circa 50€), si potrebbero avere problemi con l'hardware del computer in quanto sono richiesti componenti di alta qualità, che possono arrivare a costare anche 1500€.

Con così tanti simulatori di volo disponibili in rete, perché avremmo dovuto spendere migliaia di ore di programmazione e progettazione per costruire un simulatore di volo libero? Beh, ci sono molte ragioni, ma qui sotto riportiamo quelle principali:

- Tutti i simulatori commerciali hanno un grosso inconveniente: sono realizzati da un piccolo gruppo di sviluppatori che definiscono le loro caratteristiche in base a ciò che è importante per loro e forniscono interfacce limitate agli utenti finali. Chiunque abbia mai provato a contattare uno sviluppatore commerciale sarebbe d'accordo nel dire che far sentire la propria voce in questo ambiente rappresenta una grande sfida. Al contrario, FlightGear è stato progettato da un vasto gruppo di persone con tutti i codici liberamente disponibili e modificabili.

- I simulatori commerciali solitamente sono un compromesso di funzionalità e usabilità, spesso a causa di scadenze e finanziamenti. La maggior parte

degli sviluppatori commerciali vuole essere in grado di servire un ampio segmento della popolazione, compresi i piloti professionisti, i principianti, e anche i giocatori occasionali. Poiché FlightGear è libero e aperto, non vi è alcuna necessità di un tale compromesso. Non abbiamo nessun editore che ci mette fretta, e siamo tutti volontari in grado di scegliere da soli le nostre scadenze.

- A causa della loro natura closed-source, nei simulatori commerciali solo gli sviluppatori più esperti possono contribuire a migliorare i prodotti. In FlightGear, invece, tutti gli sviluppatori, indipendentemente dal loro livello di abilità, possono avere un enorme impatto sui progetti. Contribuire ad un progetto così grande e complesso come FlightGear è molto gratificante e offre ai programmatori un notevole orgoglio nel sapere che si sta plasmando il futuro di un ottimo simulatore.

- Al di là di tutto il resto, programmare questo simulatore è puro divertimento; certo, potevamo uscire di casa e comprare un gioco già fatto, ma abbiamo creduto che progettarne uno da soli avrebbe dato molta più soddisfazione.

I punti menzionati in precedenza costituiscono la base del motivo per cui abbiamo creato FlightGear.

Con queste motivazioni in mente, abbiamo deciso di creare un simulatore di volo di alta qualità che mira ad essere civile, multipiattaforma, aperto, ideato per gli utenti, e open source. Diamo uno sguardo più da vicino a ciascuna di queste caratteristiche:

- **Civile:** Il progetto si rivolge principalmente alle simulazioni di voli civili. Dovrebbe essere appropriato per simulare l'aviazione generale e la maggior parte degli aerei civili. Il nostro obiettivo a lungo termine è quello di ricevere la FAA (cioè la licenza che approva FlightGear come un dispositivo di addestramento al volo). Per la delusione di alcuni utenti, al momento non è un simulatore di combattimento, tuttavia, questa caratteristica non è esplicitamente esclusa. Noi semplicemente non siamo interessati a sistemi necessari per la simulazione di combattimenti.

- **Multipiattaforma:** Gli sviluppatori stanno cercando di mantenere il codice indipendente dalla piattaforma il più possibile. Questo per permettere di usare il simulatore di volo su tutti i computer, indistintamente dal sistema operativo o dall'hardware usato. Il codice attuale supporta i seguenti sistemi operativi:

  - Linux (qualsiasi distribuzione e piattaforma)
  - Windows NT/2000/XP/Seven (piattaforma Intel / AMD)
  - Windows 95/98/ME
  - BSD UNIX

- Sun-OS

- Mac OS X

Attualmente, non c'è nessun altro simulatore di volo conosciuto â commerciale o libero â che sostiene una così ampia gamma di piattaforme

- **Aperto:** Il progetto non si limita ad uno schema fisso o ad una piccola cerchia di sviluppatori. Chiunque ritiene di essere in grado di contribuire è il benvenuto. I codici (comprese le documentazioni) sono protetti da copyright sotto i termini della GNU General Public License (GPL). In termini semplici, si afferma che è possibile copiare, modificare e distribuire liberamente il programma. Tuttavia, quando si distribuisce il software è necessario rendere disponibile ai destinatari il codice sorgente originario cosicchè si possano mantenere i diritti d'autore. In breve: Si può fare qualsiasi cosa con il software tranne renderlo non-free. Il testo completo della GPL può essere ottenuto dal codice sorgente FlightGear o dal sito http://www.gnu.org/copyleft/gpl.html.

  Ideato per gli utenti e open source: A differenza di molti simulatori commerciali, paesaggi, aerei, variabili interne, API, e tutto il resto sono accessibili all'utente e documentati fin dall'inizio. Anche senza alcuna documentazione di sviluppo esplicita (che dovrà naturalmente essere scritta prima o poi), si può sempre andare a vedere il codice sorgente per vedere come funziona qualcosa. è l'obiettivo degli sviluppatori costruire un motore di base a cui scenografi, ingegneri dei pannelli, magari tecnici delle torri di controllo, ââscrittori di routine, artisti del suono, e altri possano contribuire. La nostra speranza è che il progetto, gli sviluppatori e gli utenti finali, beneficino della creatività e delle idee dei collaboratori.

Senza dubbio, il successo del progetto Linux, iniziato da Linus Torvalds, ha ispirato molti degli sviluppatori. Non solo ha dimostrato di Linux che lo sviluppo distribuito di progetti software altamente sofisticati su Internet è possibile, ma ha anche dimostrato che un tale sforzo può superare il livello di qualità dei prodotti commerciali concorrenti.
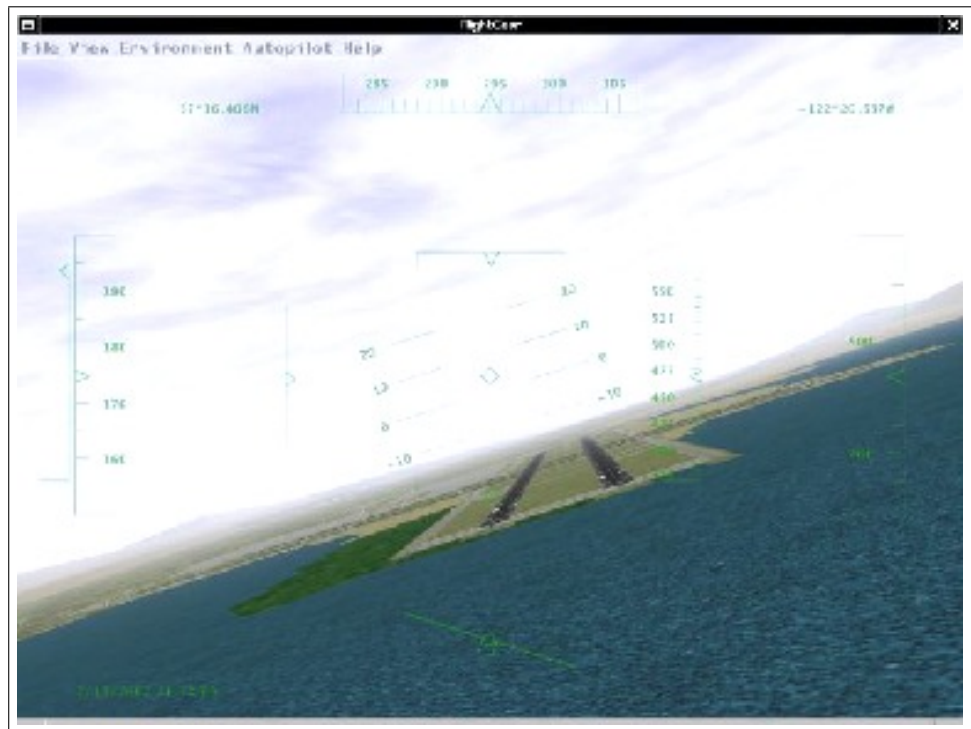
Fig. 1: FlightGear sotto UNIX: cattivo approccio al San Francisco International â scatto fatto da uno degli autori di questo manuale...

2.2 Requisiti di sistema

Rispetto ad altri recenti simulatori di volo, i requisiti di sistema per FlightGear non sono stravaganti. Un AMD Athlon64 o Intel P4 di velocità media, o comunque un discreto AMD Athlon/K7 o un Intel PIII dovrebbe essere sufficiente per gestire FlightGear abbastanza bene, mentre invece la cosa più importante è avere una scheda grafica supportata. Un presupposto importante per l'esecuzione di Flight-Gear è una scheda grafica il cui driver supporti OpenGL. Per chi non sapesse cosa è OpenGL, la panoramica fornita sul sito web

http://www.opengl.org

afferma: "Fin dalla sua introduzione nel 1992, è diventata l'industria delle più diffuse e supportate grafiche 2D/3D per le interfacce di programmazione delle applicazioni (API)...".

FlightGear non funziona su una scheda grafica che supporta solo Direct3D/DirectX. Contrariamente a OpenGL, Direct3D è un'interfaccia proprietaria, essendo progettata solo per il sistema operativo di Windows.

Si può comunque eseguire FlightGear su un computer che dispone di una scheda video 3D che non supporta l'accelerazione hardware OpenGL - e anche su si-

stemi senza un hardware grafico 3D. Tuttavia, l'assenza di accelerazione hardware OpenGL può portare anche la macchina più veloce in ginocchio. Il segnale tipico della mancante accelerazione hardware è costituito da frame rate inferiori a 1 fotogramma al secondo.

Quasi tutte le moderne schede grafiche 3D sono dotate di supporto OpenGL. Per sapere se la propria scheda grafica lo supporta, visitare la homepage del produttore della scheda video. Si richiama l'attenzione sul fatto che a volte i driver OpenGL sono forniti dai produttori di chip grafici anziché che dai creatori della scheda madre. Se avete intenzione di acquistare una scheda grafica per l'esecuzione di FlightGear, è consigliabile una scheda NVIDIA GeForce, in quanto è più probabile che supporti OpenGL rispetto ad un AMD/ATI Radeon. 256MB di memoria grafica dedicata sono più che adeguati - molte persone usano FlightGear tranquillamente anche con meno.

Per installare il paesaggio eseguibile e di base, avrete bisogno di circa 500 MB di spazio libero sul disco. Nel caso in cui si voglia/debba compilare il programma da soli saranno necessari circa altri 500 MB per il codice sorgente e per i file temporanei creati durante la compilazione. Questo non include l'ambiente di sviluppo, che varia in dimensioni a seconda del sistema operativo e all'ambiente informatico in uso. Gli utenti Windows possono aspettarsi di avere bisogno di circa 300 MB di spazio aggiuntivo sul disco per l'ambiente di sviluppo. Linux e altri sistemi UNIX dovrebbero avere la maggior parte degli strumenti di sviluppo già installati, quindi è probabile che sia richiesto meno spazio su queste piattaforme.

Per gli , qualsiasi dovrebbe essere sufficiente. Grazie al suo design flessibile, FlightGear supporta una vasta gamma di joystick e periferiche, come ad esempio le pedaliere.

FlightGear è stato sviluppato principalmente sotto Linux, un clone di UNIX libero (insieme con un sacco di GNU utility) sviluppata cooperativamente su Internet più o meno con lo stesso spirito di FlightGear. FlightGear è in parte sviluppato anche sotto varie versioni di Windows, Mac OS X e diverse postazioni di lavoro Unix/X11. Una volta installati i programmi di sviluppo, FlightGear può essere sviluppato sotto tutte queste piattaforme.

Il compilatore primario per tutte le piattaforme è la libera GNU C++ compiler (compilatore Cygnus Cygwin sotto Win32).

Se si desidera eseguire FlightGear sotto Mac OS X, è necessario disporre di Mac OS X 10.4 o superiore. I requisiti minimi hardware richiedono un 1,0 GHz G4 Power PC o un Mac Intel, ma vi consigliamo di avere MacBook Pro, iMac Intel, Mac Pro, o Power Mac (G5 Power PC) per un volo confortevole.

2.3   La scelta di una versione

Si consiglia di installare l'ultima versione ufficiale disponibile al sito :

http://www.flightgear.org/Downloads/

, che è solitamente prodotta annualmente, e che viene utilizzata per creare i file binari pre-compilati.

Se davvero si vuole ottenere l'ultima versione (generalmente è anche la più buggata), è possibile clonare i sorgenti più recenti all'indirizzo

http://www.gitorious.org/fg.

Istruzioni dettagliate su come farlo possono essere trovate qui:

http://wiki.flightgear.org/GIT.

2.4 Modelli di volo dinamici

Storicamente, FlightGear è basato su un modello di volo che ha ereditato (insieme con la Navion Airplane) dalla LaRCsim. Dato che questi aveva molte limitazioni (soprattutto, molte caratteristiche erano cablate in contrasto con i file di configurazione), ci sono stati diversi tentativi di sviluppare o includere modelli di volo alternativi. Come risultato finale, FlightGear supporta diversi modelli di volo differenti, da scegliere in fase di esecuzione.

- Forse il più importante è il modello di volo JSB sviluppato da Jon Berndt. Il modello di volo JSB è parte di un progetto autonomo denominato *JSBSim*:

  http://jsbsim.sourceforge.net/.

- Andrew Ross ha creato un altro modello di volo chiamato *YASim*. Quest'ultimo ha un approccio fondamentalmente diverso da molti altri modelli di volo, essendo basato su informazioni geometriche piuttosto che su coefficienti aerodinamici. *YASim* ha anche un modello di volo per elicotteri particolarmente avanzato.

- Christian Mayer ha sviluppato un modello di volo di una mongolfiera. Curt Olson successivamente ha integrato una speciale modalità "UFO", che aiuta a volare rapidamente dal punto A al punto B.

  Infine, vi è il modello di volo UIUC, sviluppato da un team della University of Illinois a Urbana-Champaign. Questo lavoro è stato inizialmente orientato verso i modellini di aeromobili, ma ora comprende anche aerodinamiche "non lineari", che si traducono in un maggiore realismo negli atteggiamenti estremi, come nello stallo e negli alti angoli di attacco in volo. Due buoni esempi che illustrano questa capacità sono il Airwave Xtreme 150 e il 1903 Wright Flyer. Maggiori dettagli sul modello di volo UIUC sono disponibili all'indirizzo

  http://www.ae.illinois.edu/m-selig/apasim/Aircraft-uiuc.html

É anche possibile visualizzare le scene di FlightGear con un modello di volo esterno in esecuzione su un computer diverso o tramite named pipe sulla macchina locale - anche se questo potrebbe non essere una configurazione consigliata per le persone che vogliono solo entrare in contatto con FlightGear.

2.5 Informazioni su questa guida

In questa guida c'è poco materiale. Altre informazioni aggiuntive sono presenti sul sito web di *FlightGear*

http://www.flightgear.org/

Il Manuale FlightGear è destinato ad essere un primo passo verso una completa documentazione di FlightGear.

Non abbiamo riportato tutte le informazioni qui, perché questo documento è destinato all'utente finale, che si presume non sia interessato al funzionamento interno di OpenGL né tanto meno alla programmazione del simulatore. è nostra speranza che un giorno, assieme al pacchetto base di FlightGear, sia integrato anche un manuale per i programmatori, gli sviluppatori e i disegnatori di scenari.

Vi preghiamo di aiutarci a perfezionare questa guida inviandoci correzioni, miglioramenti, suggerimenti e traduzioni. Tutti gli utenti sono invitati a contribuire anche nelle descrizioni di configurazioni alternative (schede grafiche, sistemi operativi, ecc). Saremo più che felici di includere questi nelle future versioni del Manuale di FlightGear (ovviamente non senza dare credito agli autori).

Capitolo 3

Prima di volare: installazione di *FlightGear*

Per eseguire *FlightGear*è necessario installare i file binari. Una volta fatto questo è possibile installare scenari e velivoli aggiuntivi, se lo si desidera. File binari pre-compilati per l'ultima versione sono disponibili per:

- Microsoft Windows - qualsiasi versione

- Mac OS X

- Linux

Per scaricarli, andare sul sito http://www.flightgear.org/download/main-program/ e seguire le istruzioni fornite nella pagina.

3.1 Installare scenari

ono disponibili scenari dettagliati raffiguranti tutto il mondo, che consentono di volare ovunque, dalle montagne dell'Himalaya al rurale Kansas. Il pacchetto base di *FlightGear* contiene scenari per una piccola area intorno a San Francisco, per volare altrove è necessario scaricare uno scenario aggiuntivo. Ogni pezzo di scenario 10x10 gradi (latitudine e longitudine) viene compresso in un archivio (solitamente di formato, .rar, .tar o .tgz). Ogni archivio è chiamato con le coordinate che rappresenta, per esempio "w130n50.tgz" É possibile scaricare gli scenari ufficiali da un planisfero cliccabile qua:

http://www.flightgear.org/download/scenery/

In alternativa, è possibile sostenere il progetto *FlightGear* con l'acquisto del set completo di scenari per il mondo intero da qui:

http://shopping.flightgear.org/

Dopo aver scaricato gli archivi sul computer, è necessario trovare la directory di *FlightGear* contenente gli scenari

- In Windows questa cartella è probabile che sia:

  `c:\Program Files\FlightGear\data\Scenery.`

- Per i sistemi UNIX, di solito è:

  `/usr/local/share/FlightGear/data/Scenery.`

- Per Mac OS X, è solitamente:

  `/Applications/FlightGear.app/Contents/Resources/data/Scenery.`

Per installare gli scenari, decomprimere l'archivio nella directory Scenery. La maggior parte dei sistemi operativi fornisce gli strumenti per decomprimere gli archivi. Se ciò non fosse, installare un programma estrattore come 7-zip (http://www.7-zip.org/). Si noti che non è necessario decomprimere i file numerati all'interno dell'archivio come `958402.tgz` - questo sarà fatto da FlightGear durante il volo. Dopo aver decompresso l'archivio, le directory `Terrain` e `Objects` conterranno ulteriori sotto-cartelle con il nuovo scenario all'interno. Per utilizzare il nuovo scenario, è sufficiente selezionare nella schermata di avvio del simulatore un aeroporto di partenza contenuto nello scenario. Se si utilizza il Launcher di FlightGear, sarà necessario premere il pulsante `Aggiorna` prima di selezionare l'aeroporto.

3.1.1 MS Windows Vista/7

`c:\Users\(tuo nome)\AppData\Local\VirtualStore\Program Files\FlightGear\Scenery`

Se dovesse succedere questo, è necessario copiare manualmente i file nella directory reale degli scenari di FlightGear come descritto sopra.

3.1.2 Mac OS X

è possibile installare gli scenari/aeromobili scaricati usando l'interfaccia grafica del Launcher. Premendo "Installa Add-On" nella scheda "funzioni avanzate" si dovrebbe aprire una finestra dove è possibile selezionare dei file. Selezionando uno o più scenari, questi verranno installati automaticamente in:

`/Applications/FlightGear.app/Contents/Resources/data/Scenery`

I formati accettabili per gli scenari sono: ".zip", ".rar", ".tgz", ".tar", e cartelle già estratte. Se l'installazione tramite il Launcher dovesse fallire per qualche motivo, è possibile installarli manualmente. Per far ciò, bisogna aprire la cartella dati di FlightGear, premendo Apri cartella dati nella scheda "Altro" del simulatore. Una volta aperta la cartella, è possibile copiare i paesaggi/aerei al suo interno.

3.1.3 FG_SCENERY

Se si preferisce mantenere gli scenari scaricati separati dall'installazione di base, è possibile farlo impostando la variabile d'ambiente `FG_SCENERY`.

Questa variabile contiene i posti dove FlightGear cerca i file degli scenari. Essa consiste di un lista di directory che saranno esaminate in ordine. Le directory sono separate da ":" su Unix (incluso Mac OS X) e da ";" su Windows.

Ad esempio, su Linux la variabile `FG_SCENERY` impostata così:

`/home/jsmith/WorldScenery:/usr/local/share/Flightgear/data/Scenery`

cercherà gli scenari prima in:
`/home/jsmith/WorldScenery`
E poi in:
`/usr/local/share/Flightgear/data/Scenery`.

`c:\Program Files\FlightGear\data\Scenery;c:\data\WorldScenery`
Cercherà gli scenari prima in: `c:\Program Files\FlightGear\data\Scenery`
E poi in: `c:\data\WorldScenery`

Come impostare le variabili di ambiente sule diverse piattaforme va oltre lo scopo di questo manuale.

3.1.4 Scaricare scenari mentre si vola

FlightGear è in grado di installare gli scenari mentre si vola, se si dispone di una buona connessione a Internet. Creare una directory "working" vuota e scrivibile per *TerraSync*, e impostarla affinché FlightGear vi cerchi gli scenari utilizzando la variabile `FG_SCENERY` (come spiegato sopra). Non lasciate che *TerraSync* scarichi gli scenari nella directory "Scenery" pre-installata. All'interno di FlightGear stesso, selezionare l'opzione "Download Scenari" nel menù "Ambiente". Poi basta selezionare la directory creata sopra e abilitare il download automatico degli scenari.

Uno dei principali vantaggi di *TerraSync* è che si ottiene sempre l'ultima versione dello scenario dal database mondiale di FlightGear.

Eseguire *TerraSync* come uno strumento separato

è anche possibile utilizzare TerraSync come uno strumento esterno.

Su Mac OS X o su Windows, si può fare semplicemente selezionando la casella "TerraSync" nella schermata di avvio del programma.

In alternativa è possibile eseguire direttamente il programma TerraSync. Esso comunica con FlightGear utilizzando il protocollo 'Atlas' e usando i seguenti parametri da riga di comando (modificare il numero della porta usata):

`--atlas=socket,out,1,localhost,5505,udp`

Si raccomanda inoltre di modificare la directory con il seguente comando:

```
terrasync -p 5505 -S -d /usr/local/share/TerraSync
```

Notare che TerraSync (quando chiamato con la "-S" dalla riga di comando, come raccomandato) scarica gli scenari tramite il protocollo HTTP. Così, se l'accesso a Internet è configurato per utilizzare un proxy HTTP bisognerà configurare la libsvn per l'utilizzo di un proxy. Se si utilizza Mac OS X 10.5, il programma di avvio specifica "-S" automaticamente se svn è disponibile.

3.1.5   Creare il proprio scenario

Se siete interessati a sviluppare degli scenari, date un'occhiata a TerraGear, lo strumento che genera il paesaggio per *FlightGear*:

http://wiki.flightgear.org/TerraGear

I codici sorgenti più aggiornati e usati della serie di strumenti "TerraGear" sono visibili sul "FlightGear Landuse Data Mapserver":

http://mapserver.flightgear.org/git/gitweb.pl.

3.2   Installare altri aerei

Il pacchetto FlightGear di base contiene solo un piccolo sottoinsieme di tutti velivoli che sono disponibili per FlightGear. Gli sviluppatori hanno creato una vasta gamma di aerei, dai combattenti della seconda guerra mondiale, come lo Spitfire, ad aerei passeggeri come il Boeing 747.

è possibile scaricare altri aeromobili da:

http://www.flightgear.org/download/aircraft/

Basta scaricare i file e decomprimerli nella cartella "Aircraft" all'interno della directory d'installazione. Gli aerei vengono scaricati solitamente come archivi .zip. Sarà possibile usare gli aerei appena installati alla prossima esecuzione del simulatore.

Su Mac OS X, è possibile utilizzare l'apposito pulsante situato nella schermata d'avvio di FlightGear per installare gli aerei scaricati come descritto nella sezione

3.3   Installare documentazioni aggiuntive

La maggior parte dei pacchetti sopra citati includono la documentazione completa di FlightGear. É anche possibile visualizzare la guida completa di FlightGear in formato HTML tramite il menù "Aiuto" del gioco. Inoltre, il codice sorgente del simulatore contiene la directory "docs-mini" che comprende numerose idee e soluzioni a problemi specifici e ulteriori approfondimenti.

Parte II

II Volare con *FlightGear*

Capitolo 4

Inizio: come avviare il programma

4.1 Variabili d'ambiente

Ci sono due variabili d'ambiente che devono essere definite per eseguire Flight-Gear. Queste dicono a *FlightGear* dove trovare i dati e i paesaggi. è possibile impostarle in vari modi a seconda della piattaforma e delle proprie esigienze.

4.1.1 FG_ROOT

Questa variabile indica a *FlightGear* dove trovare i file dati come aerei, luoghi di navigazione, e frequenze aeroportuali. Di default è una sottodirectory della cartella di installazione di *FlightGear*, ad esempio `/usr/local/share/FlightGear/data` o `c:\Program Files\FlightGear\data`.

4.1.2 FG_SCENERY

Questa variabile indica a FlightGear dove cercare i file degli scenari. Si compone di una lista di directory che saranno controllate nell'ordine in cui sono scritte. Le directory sono separati da ":" in Unix e da ";" su Windows, ecco due esempi:

`/home/joebloggs/WorldScenery:/usr/local/share/FlightGear/data/Scenery`

o

`c:\Program Files\FlightGear\data\Scenery;c:\Program Files\FlightGear\data\WorldScenery`.

4.1.3 Variabili di ambiente Windows e Mac OS X

La procedura guidata su Windows e l'interfaccia grafica di avvio su Mac OS X semplifica la vita all'utente definendo internamente queste variabili d'ambiente. Tuttavia, nel caso in cui si avvii FlightGear da riga di comando, è necessario definirle in modo esplicito.

4.2   Avvio del simulatore in ambiente Unix / Linux

Fig. 3 : Pronti al decollo: *avvio predefinito a San Francisco Intl, KSFO.*

Prima di poter eseguire FlightGear, è necessario impostare un paio di variabili d'ambiente:

- è necessario aggiungere `/usr/local/share/FlightGear/lib` er la variabile `LD_LIBRARY_PATH`

- `FG_ROOT` ddeve essere impostata con il percorso della directory d'installazione di *FlightGear*. (Ad esempio : `/usr/local/share/FlightGear/data`).

- `FG_SCENERY` deve contenere una lista di percorsi di cartelle, separati da ":". Questa variabile indica a FlightGear dove cercare gli scenari. (Esempio di variabile su linux: `$FG_ROOT/Scenery:$FG_ROOT/WorldScenery`).

Per aggiungere queste variabili nella Bourne shell (e compatibili):

```
LD_LIBRARY_PATH=/usr/local/share/FlightGear/lib:$LD_LIBRARY_PATH
export LD_LIBRARY_PATH
FG_HOME=/usr/local/share/FlightGear
export FG_HOME
FG_ROOT=/usr/local/share/FlightGear/data
```

```
export FG_ROOT
FG_SCENERY=$FG_ROOT/Scenery:$FG_ROOT/WorldScenery
export FG_SCENERY
```

Per aggiungere queste variabili nella C shell (e compatibili):

```
setenv LD_LIBRARY_PATH=\
  /usr/local/share/FlightGear/lib:$LD_LIBRARY_PATH
setenv FG_HOME=/usr/local/share/FlightGear
setenv FG_ROOT=/usr/local/share/FlightGear/data
setenv FG_SCENERY=\
  $FG_HOME/Scenery:$FG_ROOT/Scenery:$FG_ROOT/WorldScenery
```

Una volta impostate queste variabili d'ambiente, è sufficiente avviare *Flight-Gear* eseguendo

```
fgfs --option1 --option2...
```

Le opzioni della riga di comando sono descritte nel capitolo 4.4.

I binari pre-costruiti per Windows sono dotati di una interfaccia grafica guidata per avviare FlightGear. è sufficiente fare doppio clic sulla voce del menu del FlightGear Launcher nella barra di Start o sull'icona sul desktop. Il programma di avvio consente di selezionare il vostro aereo, l'aeroporto di partenza e la pista, l'ora del giorno, le condizioni meteo, e un sacco di altre impostazioni.
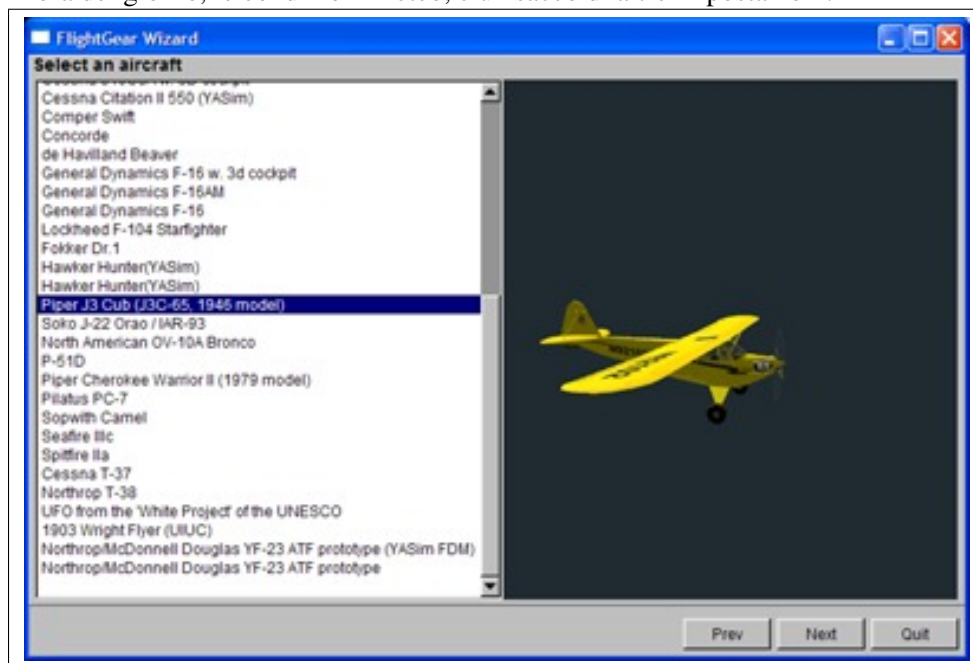
Fig. 4: *Il launcher di FlightGear sotto Windows*

Al primo avvio, verrà chiesto di impostare la variabile `FG_ROOT` (generalmente `c:\Program Files\FlightGear\data`) e la variabile `FG_SCENERY`.

Quest'ultima dovrebbe essere un elenco delle directory dove avete installato i pae-
saggi, solitamente

        `c:\Program Files\FlightGear\data\Scenery.`

È possibile modificare le impostazioni successivamente premendo il tasto -
Precedente nella prima pagina del programma.

4.2.1   Avvio dalla riga di comando

In alternativa, è possibile eseguire FlightGear dalla riga di comando. Per fare que-
sto, è necessario impostare le variabili `FG_ROOT` e `FG_SCENERY` manualmente.

Aprire il prompt dei comandi, passare alla directory in cui risiedono i binari di
FlightGear (normalmente `c:\Program Files\FlightGear\bin\Win32`)
E impostare le variabili d'ambiente digitando

```
SET FG_HOME="c:\Program Files\FlightGear"
SET FG_ROOT="c:\Program Files\FlightGear\data"
SET FG_SCENERY="c:\Program Files\FlightGear\data\Scenery"
```

e richiamare FlightGear (all'interno dello stesso prompt dei comandi, dato che
impostazioni d'ambiente sopra dichiarate ono valide solo localmente all'interno
della stessa shell) tramite

        `fgfs --option1 --option2...` Le opzioni della riga di comando so-

no descritte nel capitolo 4.4.

Naturalmente, è possibile creare un file batch con un editor di testo di Windows
(come notepad) utilizzando i comandi di cui sopra. Per le massime prestazioni si
consiglia di ridurre al minimo (Iconize) la finestra di output di testo (il prompt)
durante l'esecuzione del simulatore.

4.3   Avvio del simulatore sotto Mac OS X

LIl pacchetto binario precompilato per Mac OS X viene fornito con l'interfaccia di
avvio guidata. Semplicemente facendo doppio clic sull'icona di FlightGear nella
cartella /Applications si dovrebbe aprire la finestra di avvio come mostrato in Fig.
5. Il Launcher permette di:

- Selezionare un aereo e un aeroporto

- Attivare/Disattivare il download automatico degli scenari (usando *TerraSync*)

- Abilitare/Disabilitare la mappa di navigazione (Atlas)

- Lanciare *FlightGear*
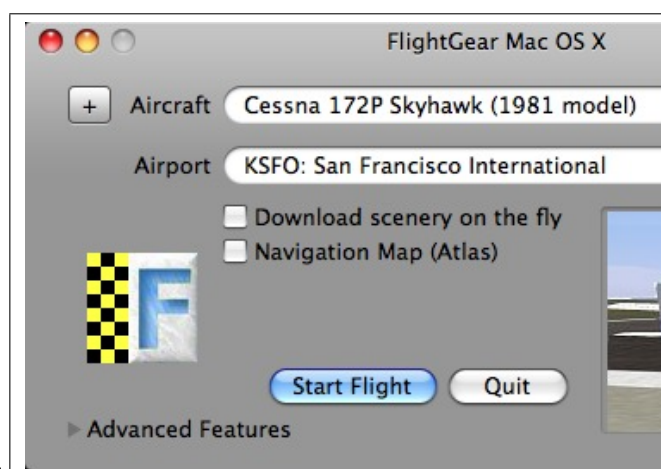
Le sezioni seguenti descrivono l'uso di queste funzioni.

Fig. 5: *Il Launcher per Mac OS X*

4.3.1 Selezione di un aereo e di un aeroporto

Nella finestra di avvio, è possibile selezionare un aereo e un aeroporto facendo clic sull'immagine dell'ingranaggio all'estremità destra del nome dell'aeroporto/aereo. L'immagine in miniatura dell'aereo selezionato apparirà in basso sulla destra nella finestra. L'aeroporto selezionato qui sarà il punto di partenza del volo. FlightGear usa i codici ICAO di 4 lettere per distinguere gli aeroporti, ciascun codice è composto da una o due lettere di prefisso seguite da un codice aeroportuale di due o tre lettere. Ad esempio, il codice ICAO per San Francisco International Airport è KSFO. K in questo caso è il prefisso per gli Stati Uniti, e OFS è il codice dell'aeroporto di San Francisco International Airport. è possibile utilizzare le funzionalità avanzate per trovare un aeroporto o un aereo.

4.3.2 Attivazione del download degli scenari in volo

Spuntando l'opzione "Scarica scenari durante il volo" nella finestra di avvio, i paesaggi verranno scaricati mentre si sta volando con TerraSync. Questi verranno installati in

```
/Applications/FlightGear.app/Contents/Resouces/data/Scenery-Terrasync.
```

4.3.3 Attivazione della mappa di navigazione (Atlas)

La versione Mac di FlightGear comprende Atlas, la mappa di navigazione che aiuta il vostro piano di volo, per la vostra convenienza. Selezionando questa opzione si avvia automaticamente Atlas quando si avvia il volo. Non è necessario specificare ulteriori opzioni. Il Launcher le imposterà automaticamente.

4.3.4   Avviare FlightGear - il simulatore

Cliccando sul pulsante *Start Flight* nella finestra di avvio, si apre un'altra finestra - quella principale di FlightGear. FlightGear inizia subito il caricamento di tonnellate di dati necessari per la simulazione. Questa operazione può richiedere anche alcuni minuti sulle macchine più lente.

4.3.5   Funzioni avanzate

FlightGear ha molte caratteristiche e opzioni che è possibile specificare in fase di avvio.

Alcune di queste non sono modificabili dal menu nella finestra principale di FlightGear.

Per abilitare/disabilitare queste funzionalità, fare clic sul pulsante a forma di triangolo in basso a sinistra nella finestra di avvio. Questo mostra tutte le funzionalità avanzate. Tutte le impostazioni vengono salvate in modo da non doverle specificare nuovamente.

Le sottoschede: Generale, Caratteristiche, Rendering

Queste schede consentono di specificare alcune opzioni *FlightGear* :

- **Salva preferenze all'uscita**: consente a *FlightGear* di salvare le preferenze che sono state modificate nei menù della finestra principale del simulatore. Queste varranno salvate in
  `$HOME/.fgfs/autosave.xml`.

- **Controllo**: specifica quale dispositivo di controllo si intende utilizzare in *FlightGear*. Le opzioni disponibili sono: . *Auto, Joystick, Mouse e Tastiera* É preferibile lasciare l'opzione predefinita (Auto) a meno che non si voglia veramente cambiarla manualmente

- **Unità**: specifica l'unità utilizzata in *FlightGear*. Le opzioni disponibili sono *Piedi* e *Metri*.

- **Ora del giorno**: indica l'ora del giorno nel simulatore. Le opzioni disponibili sono: *Ora reale, Alba, Mattina, Mezzogiorno, Pomeriggio, Tramonto, Sera e Mezzanotte*.

- **Stagione**: indica la stagione usata dal simulatore. è possibile scegliere tra estate o inverno.

- **Audio**: la disattivazione di questa opzione toglierà tutto il suono in *FlightGear*.

- **Pannello strumentale**: specifica se attivare il pannello 2D. è comunque possibile abilitarlo/disabilitarlo durante il volo tramite il menù dellafinestra principale .

- **Oggetti Random**: specifica se *FlightGear* disegni oggetti casuali o meno.

- **Modelli AL**: specifica se *FlightGear* debba gestire aerei e navi casuali.

- **Orologio congelato**: specifica se l'orologio debba avanzare in *FlightGear* o meno.

- **Carburante congelato**: se attivo l'aereo non consuma carburante in volo.

- **Avviare in stato congelato**: inizia *FlightGear* in pausa. Questa opzione è in fase di sviluppo e non sembra funzionare attualmente

- **Visualizza HUD**: fa scegliere se visualizzare l'HUD fin dall'inizio del volo. è comunque possibile attivare/disattivare l'HUD durante il volo premendo il tasto "h".

- **3D HUD:** abilita l'HUD tridimensionale se l'aeromobile selezionato lo supporta.

- **Recupera le informazioni meteo reali**: abilita il recupero delle condizioni atmosferiche reali utilizzando METAR .

- **Effetto Horizon**: abilita l'effetto orizzonte.

- **Nuvole**: se attiva disegna nuvole casuali in cielo.

- **Nubi 3D**: consente di disegnare nuvole 3D. Per visualizzarle è necessario abilitare anche l'opzione "nuvole 3D" nella scheda di Rendering.

- **Turbolenze**: specifica la forza delle turbolenze. è necessario specificare un valore tra 0.0 (turbolenze assenti) e 1.0 (turbolenze forti)

- **Visibilità**: specifica la visibilità in metri. è consigliato specificare 5000 o meno, sui computer meno potenti.

- **Modalità a schermo intero**: l'attivazione di questa opzione lancerà *FlightGear* in modalità a schermo intero.

- **Dimensioni finestra**: specifica la dimensione della finestra di *FlightGear*. Sarà ignorata quando la modalità a schermo intero è attivata.

- **Miscelazione cielo**: NON disabilitare questa opzione, o si bloccherà *FlightGear*.

- **Textures**: attiva o disattiva le texture su piste, edifici e oggetti degli scenari. La disattivazione di questo vi darà qualche fps in più, visibile soprattutto su Mac G4.

- **Wireframe**: permette a *FlightGear* di disegnare wireframe in modo da poter vedere come viene disegnato il mondo di *FlightGear*. Questo dovrebbe essere attivato solo per scopi di debug/sviluppo.

- **Nebbia**: specifica come la nebbia viene disegnata. Le opzioni disponibile sono: *nebbia disabilitata, grafica nebbia massima, grafica nebbia minima*.

Scheda Preferiti

Questa scheda fornisce un comodo mezzo per salvare un set di opzioni come un segnalibro di un browser web. Per salvare l'attuale serie di opzioni, premere il pulsante "+" nella scheda. Una volta salvate le opzioni, è possibile passare da una configurazione all'altra facendo doppio clic su una riga nella tabella "Visualizza" della scheda. Premendo il pulsante "-" (o il tasto Canc) su un favorito all'interno della tabella, si elimina il preferito selezionato.

Scheda Posizione

É possibile trovare aeroporti o portaerei cercando tramite una parola chiave digitandola nell'area di testo del filtro. Le parole chiave disponibili sono:

- Per gli aeroporti:

    - Una parte del nome dell'aeroporto,
    - Nome del paese in cui risiede l'aeroporto (come Giappone, Stati Uniti, o Francia),
    - Nome del luogo, (ad esempio una città o una provincia),
    - Codice IATA dell'aeroporto (come SFO, LAX, HND),
    - Codice ICAO dell'aeroporto (come KSFO, KLAX, RJTT).

- Per le portaerei:

    - Nome della portaerei (Nimitz o Eisenhower),
    - "Carrier" o "Portaerei".

Gli aeroporti e le portaerei che corrispondono alla ricerca vengono visualizzate in una tabella sotto l'area di testo del filtro. Quando si sceglie un aeroporto, le piste disponibili sono visibili cliccando sul pulsante "Piste". è possibile scegliere una pista o lasciare come "default".

- Una parte del nome dell'aeromobile (ad esempio C172, zero, Shinden)

- Nome del file di configurazione senza -set.xml (per esempio A6M2, P51D)

- Fdm (Flight Dynamics Model), ad esempio Yasim o JSB

- Stato (ad esempio Alfa, Beta, Produzione, Sviluppo)

UL'elenco degli aeromobili corrispondenti alla ricerca verrà visualizzato in una tabella sotto l'area di testo del filtro. Selezionando un aereo dall'elenco si seleziona anche l'aereo da usare durante la simulazione.

Se si desidera scaricare aeromobili aggiuntivi da Internet, fare clic sul pulsante "Get Aircraft" (in italiano: "Ottieni altri aerei") nella parte inferiore della scheda. Così facendo, si aprirà un browser web in una nuova finestra per condurvi alla pagina per scaricare aerei sul sito web di FlightGear Mac OS X. Per scaricare l'aereo desiderato cliccare sul link "Download" presente sotto l'immagine dell'aereo stesso. Una volta che un aeromobile viene scaricato, è possibile installarlo tramite la scheda "Altro".

Se doveste notare qualche strano comportamento durante la ricerca di un aereo, la rimozione del file di cache del database degli aerei potrebbe risolvere il vostro problema. Per far ciò, aprire `/Applications/Utilities/Terminal.app` e digitare il seguente comando:

```
cd /Applications/FlightGear.app/Contents/Resources
rm AircraftCache.rb
```

Scheda di rete (Network)

Questa scheda contiene le impostazioni di due funzioni di rete di FlightGear. Una è la modalità multigiocatore e l'altra è FGCOM (un programma che gestisce le voci del simulatore). Per attivare la modalità multiplayer, specificare i seguenti dati:

- **Abilita Multigiocatore**: attiva o disattiva la modalità multiplayer. L'attivazione di questa opzione aprirà una nuova finestra del browser per visualizzare la mappa su un server multigiocatore.

- **Calsign**: contiene il proprio username che verrà visualizzato dagli altri utenti e indicato sulla mappa. Può contenere solo lettere dell'alfabeto, numeri, caratteri di sottolineatura e punti. Un nome utente con 8 o più caratteri verrà troncato nei primi 7 caratteri.

- **Server**: specifica il server a cui connettersi. mpserver02.flightgear.org è il server principale consigliato al momento della stesura di questo manuale.

- **Your Mac** : specifica l'indirizzo IP del vostro Mac. Di solito il programma di avvio rileva automaticamente l'indirizzo; tuttavia, se ciò non dovesse accadere, è possibile impostarlo manualmente tramite questo campo.

- **Porta**: deve essere 5000.

FGCOM consente di effettuare una vera e propria comunicazione vocale utilizzando le frequenze radio.

Si può parlare a una frequenza radio selezionata (COM1) premendo la barra spaziatrice. È possibile inoltre ascoltare gli altri giocatori connessi alla stessa frequenza. Le opzioni disponibili per FGCOM sono elencate di seguito:

- **FGCOM attivo in modalità multiplayer**: specifica se utilizzare FGCOM quando il multigiocatore è abilitato.

- **FGCOM Server**: specifica un server VOIP.

Per ulteriori istruzioni su FGCOM, e sulle impostazioni multiplayer, consultare il Capitolo 6.

Scheda Altro

In questa scheda è possibile specificare opzioni aggiuntive diverse dagli aerei, aeroporti e impostazioni del programma di avvio. É possibile vedere tutte le opzioni disponibili premendo il tasto "Vedi opzioni". Alcune opzioni potrebbero causare un crash di FlightGear. Se ciò dovesse accadere con una specifica opzione, fatecelo sapere.

Sempre attraverso questa scheda, è possibile installare velivoli e scenari premendo il tasto "Installa dati". è possibile specificare più file e/o cartelle contenenti i dati da installare.

I tipi di file accettati sono:

- zip

- tar

- tar.gz

- tar.bz2

- dossier

- 7zip (seulement si 7zip est installé)

É possibile installare più aerei e scenari contemporaneamente. Se si seleziona un archivio compresso che non contiene file di aeromobili, verrà estratto nella cartella dati di FlightGear, ma verrà ignorato. Una volta terminata l'installazione dei nuovi aeromobili, è possibile utilizzarli subito selezionandoli nella scheda "Aeroplani".

4.3.6 Avvio dalla riga di comando

Su Mac OS X è anche possibile avviare il simulatore dalla riga di comando. Per farlo, aprire Terminal.app (si trova in `/Applications/Utilities`) e digitare i seguenti comandi:

```
cd /Applications/FlightGear.app/Contents/Resources
./fgfs --option1 --option2 ....
```

Vedere il capitolo 4.4 per informazioni dettagliate sulle opzioni della riga di comando. A differenza delle altre piattaforme, non è necessario specificare manualmente le variabili di ambiente come FG_ROOT e FG_SCENERY se si utilizza un pacchetto binario precompilato.

4.4 Parametri della riga di comando

Di seguito è riportato un elenco completo e una breve descrizione delle numerose opzioni della riga di comando disponibili per FlightGear. La maggior parte di queste opzioni è impostabile anche attraverso i binari precompilati di FlightGear. Se si dispone di opzioni che si utilizzano spesso, è possibile creare un file di preferenze contenente una serie di opzioni della riga di comando che verranno impostate automaticamente. è possibile creare il file con qualsiasi editor di testo (per esempio: blocco note, emacs, vi).

- Sui sistemi Unix (incluso Mac OS X), scrivere le opzioni della riga di comando in un file con estensione `.fgfsrc` posizionato nella cartella d'installazione del simulatore.

- In Windows, mettere le opzioni della riga di comando in un file chiamato `system.fgfsrc` posizionato nella directory FG_ROOT (ad esempio, `c:\Program Files\FlightGear\data`).

4.4.1 Opzioni generali

- `--help`

  Visualizza una breve spiegazione delle più importanti opzioni della riga di comando.

- `--help --verbose`

  Visualizza una breve spiegazione di tutte le opzioni della riga di comando.

- `--version`

  Visualizza la versione corrente di FlightGear.

- `--fg-root=`*PERCORSO*

  Indica la cartella d'installazione di FlightGear.

- `--fg-scenery=`*PERCORSO* Consente di specificare il percorso dove Flight-Gear deve cercare gli scenari, nel caso in cui questi non fossero nella posizione di default sotto `$FG_ROOT/Scenery`, questo potrebbe essere particolarmente utile nel caso in cui si disponga di scenari installati su un CD-ROM.

- `--fg-aircraft=`*PERCORSO*

  Consente di indicare a FlightGear la cartella contenente gli aeromobili. Il valore predefinito è `$FG_ROOT/Aircraft`.

- `--language=`*code*

  Imposta la lingua per questa sessione. Ad esempio pl, nl, it, fr, en, de.

- `--restore-defaults`

  Ripristina tutte le impostazioni utente alle impostazioni predefinite.

- `--enable-save-on-exit`, `--disable-save-on-exit`

  Attiva o disattiva il salvataggio automatico delle preferenze dell'utente all'uscita dal simulatore.

- `--enable-freeze`, `--disable-freeze`

  Controlla se FlightGear deve iniziare in pausa o no. Il valore predefinito è "non in pausa".

- `--enable-auto-coordination`, `--disable-auto-coordination`

  Abilita/disabilita l'auto-coordinamento tra gli alettoni e il timone. L'Auto-coordinamento è consigliato per gli utenti senza pedaliera o un joystick 'twist'. Il valore predefinito è "off".

- `--browser-app=`*PERCORSO*

  ndica la posizione del tuo browser web. Per esempio: `--browser-app=` "`C:\Program Files\Internet Explorer\iexplore.exe`" (Prestare attenzione alle virgolette!).

- `--config=`*path*

  LCaricare un file contenente proprietà aggiuntive dato un determinato percorso. Per esempio: `--config=./Aircraft/X15-set.xml`

- `--units-feet`

  Imposta come unità di misura i piedi.

- `--units-meters`

  Imposta come unità di misura i metri.

4.4.2　Caratteristiche

- `--enable-ai-models`, `--disable-ai-models`

  Attiva/disattiva la visualizzazione degli altri modelli di aerei nel simulatore.

- `--ai-scenario=`*nome*

  Imposta uno scenario specifico (ad esempio: `--ai-scenario=vinson-demo`).
  Può essere utilizzato più volte.

4.4.3 Suono

- `--enable-sound`, `--disable-sound`

  Attiva/Disattiva i suoni del simulatore.

- `--show-sound-devices`

  Mostra i dispositivi audio disponibili.

- `--sound-device=`*device*

  Imposta il dispositivo audio da utilizzare.

- `--enable-intro-music`, `--disable-intro-music`

  Attiva/disattiva la riproduzione di una musichetta quando FlightGear si avvia.

4.4.4 Aerei

- `--aircraft=`*aeromobile*

  Carica il velivolo specificato, ad esempio:: `--aircraft=c172p`. Per le scelte disponibili controllare la directory `$FG_ROOT/Aircraft`, e cercare i file che terminano in "`-set.xml`". Quando si specifica il velivolo, eliminare il "`-set.xml`" dal nome del file. In alternativa, utilizzare l'opzione `--show-aircraft` descritta di seguito per elencare i velivoli disponibili. Per informazioni sul download dei velivoli, vedere la sezione 3.2.

- `--show-aircraft`

  Visualizza un elenco ordinato dei tipi di aeromobili attualmente disponibili.

- `--min-status=`*status*

  Visualizza solo gli aeromobili con determinato stato(per esempio: `alpha`, `beta`, `early-production`, `production`. Da utilizzare con `--show-aircraft`.

- `--aircraft-dir=`*PATH*

  Indica il percorso dove FlightGear deve cercare gli aerei. Il valore predefinito è `$FG_ROOT/Aircraft`.

- `--vehicle=`*name of aircraft definition file*

  Ha la stessa funzione di `--aircraft`.

- `--livery=`*Name*

  Imposta l'aspetto dell'aeromobile (colorazione).

4.4.5 Modello di volol

- `--fdm=`*abcd*

  Seleziona il modello di base di volo . Le opzioni disponibili sono: `jsb`,
  `larcsim`, `yasim`, `magic`, `balloon`, `external`, `pipe`, `ada`, `null`.
  TQuesta opzione può essere normalmente ignorata, dato che l'opzione `--aircraft`
  impostare automaticamente il FDM.

- `--aero=`*aircraft*

  Specifica il modello aeronautico dell'aereo da caricare. Questa opzione può
  essere normalmente ignorata, dato che l'opzione `--aircraft` dovrebbe
  impostare automaticamente il modello dell'aeromobile.

- `--model-hz=`*n*

  Esegue l'FDM con il tasso indicato (iterazioni al secondo).

- `--speed=`*n*

  Imposta la velocità dell'FDM rispetto al tempo reale.

- `--trim`, `--notrim`

  Trim (o meno) durante l'inizializzazione di JSBSim. L'opzione predefinita è
  "trim".

- `--on-ground`, `--in-air`

  Specifica se partire al livello del suolo (default), o in aria. Se si specifi-
  ca `--in-air` necessario impostare anche una quota iniziale utilizzando
  `--altitude` , e si consiglia inoltre di impostare una velocità iniziale con
  `--vc`. Si noti che alcuni aerei (in particolare l'X15) devono essere avviati a
  mezz'aria.

- `--enable-fuel-freeze`, `--disable-fuel-freeze`

  Controlla se il combustibile debba essere consumato normalmente (default)
  o debba essere in quantità costante (congelato).

4.4.6 Posizione iniziale e orientamento

- `--airport=`*ICAO*

  Inizia in un determinato aeroporto. L'aeroporto è specificato dal suo codice
  ICAO, ad esempio: `--airport=KJFK` per l'aeroporto JFK di New York.
  Per trovare un aeroporto degli Stati Uniti senza avere il codice ICAO, provate
  anteponendo un codice di 3 carattere con 'K'.

- `--parking-id=`*NUMERO ID*

  Inizia nel posto di parcheggio indicato. Da usare con il comando --airport

- `--runway=`*SIGLA*

  SInizia sulla soglia della pista indicata (ad esempio 28L). Se non viene specificata nessuna pista, si inizierà sulla pista con minor vento.

- `--vor=`*ABCD*, `--ndb=`*ABCD*, `--fix=`*ABCD*

  Imposta la posizione di partenza rispetto ad un VOR, NDB o FIX. Utile per praticare approcci.

- `--carrier=`*NAME*

  Inizia su una portaerei. Vedere la sezione 6.2 per i dettagli delle operazioni sulle portaerei.

- `--parkpos=`*NAME*

  Inizia in una particolare posizione di parcheggio sul supporto della portaerei. Deve essere usato assieme al comando `--carrier`. Il valore predefinito è la posizione di lancio.

- `--offset-distance=`*nm*, `--offset-azimuth=`*gradi*

  Inizia a una determinata distanza e direzione da una posizione impostata con `--airport`, `--vor`, `--ndb`, `--fix`, `--carrier`.

- `--lon=`*gradi*, `--lat=`*gradi*

  Inizia in un particolare longitudine e la latitudine espressa in gradi decimali (sud, ovest negativo).

- `--altitude=`*feet*

  Inizia in quota specifica. Da usare con il comando `--in-air`. L'altitude può essere specificata in piedi o in metri a seconda dell'unità di misura selezionata nelle impostazioni. Si consiglia inoltre di impostare una velocità iniziale con `--vc` per evitare lo stallo immediato.

- `--heading=`*gradi*, `--roll=`*gradi*, `--pitch=`*gradi*

  Imposta l'orientamento iniziale dell'aeromobile. Tutti i valori di default sono: 0 gradi in direzione Nord, in volo rettilineo e livellato.

  Set the initial orientation of the aircraft. All values default to 0 - heading North, in straight and level flight.

- `--uBody=`*X*, `--vBody=`*Y*, `--wBody=`*Z*

  Imposta la velocità iniziale lungo gli assi X, Y e Z. La velocità è in piedi al secondo a meno che non sia stata selezionata l'unità di misura in metri, nel qual caso l'altitudine sarà espressa in metri al secondo.

- `--vNorth=`*N*, `--vEast=`*E*, `--vDown=`*D*

  Imposta la velocità iniziale lungo i punti cardinali e gli assi verticali. La velocità è in piedi/metri al secondo in base a quale unità di misura è stata scelta nelle impostazioni.

- `--vc=`*knots*, `--mach=`*num*

  Imposta la velocità iniziale in nodi o in Mach. Utile da usare assieme al comando –altitude, a meno che non si voglia andare in stallo fin dalla partenza.

- `--glideslope=`*degrees*, `--roc=`*fpm*

  Imposta l'angolo di discesa iniziale in gradi o come rateo di salita espresso in piedi al minuto. Può essere positivo o negativo.

4.4.7   Opzioni d'ambiente

- `--ceiling=`*Altezza in piedi[:spessore in piedi]*

  Imposta un banco di nuvole ad una particolare altezza, e con uno spessore opzionale (di default è 2000ft).

- `--enable-real-weather-fetch`, `--disable-real-weather-fetch`

  Controlla se debbano essere scaricate e utilizzate le informazioni del meteo in tempo reale o no.

- `--metar=`*STRINGA METAR*

  Utilizza una stringa METAR specifica, ad esempio `--metar=XXXX 012345Z 00000KT 99SM CLR 19/M01 A2992`. Il METAR può essere specificato nei formati più comuni (Stati Uniti, Europa). Incompatibile con `--enable-real-weathe`

- `--random-wind`

  Imposta un vento con direzione e forza casuali.

- `--turbulence=`*n*

  Imposta una turbolenza da assente (0.0) a forte (1.0).

- `--wind=`*DIREZIONE@VELOCITÀ*

  Configura il vento di superficie. La direzione deve essere espressa in gradi e la velocità in nodi. I valori possono essere specificati come un intervallo utilizzando un separatore; Esempio: `--wind=180:220@10:15`.

- `--season=`*PARAMETRO*

  mposta la stagione da usare durante il volo. I parametri validi sono: `summer` (default), `winter`.

- `--visibility=`*meters*, `--visibility-miles=`*miles*

  Imposta la visibilità che il simulatore deve usare.

4.4.8   Opzioni di rendering

- `--aspect-ratio-multiplier=`*N*

  Imposta un moltiplicatore per il rapporto dello schermo.

- `--bpp=`*PROFONDITÀ*

  Specifica i bit per pixel da utilizzare.

- `--enable-clouds, --disable-clouds`

  Attiva (default) o disattiva la visualizzazione delle nuvole.

- `--enable-clouds3d, --disable-clouds3d`

  Attiva (default), o disabilita le nuvole 3D. Le nuvole tridimensionali sono molto belle e realistiche, ma dipenderà dalla vostra scheda grafica, perchè le schede più vecchie o meno potenti non le supportano.

- `--enable-distance-attenuation, --disable-distance-attenuation`

  Attiva/disattiva l'attenuazione delle luci rendendo le piste più realistiche.

- `--enable-enhanced-lighting, --disable-enhanced-lighting`

  Attiva/disattiva un effetto che rende le luci più realistiche durante gli approcci.

- `--enable-fullscreen, --disable-fullscreen`

  Attiva/disattiva (default) la visualizzazione a schermo intero.

- `--enable-game-mode, --disable-game-mode`

  Attiva/disattiva la visualizzazione a schermo intero per le schede grafiche 3Dfx.

- `--enable-horizon-effect, --disable-horizon-effect`

  Abilita (default)/disabilita la visuale in prospettiva.

- `--enable-mouse-pointer, --disable-mouse-pointer`

  Attiva/disattiva (default) il puntatore del mouse in più. Utile in modalità a schermo intero per le vecchie schede basate su Voodoo.

- `--enable-panel, --disable-panel`

  Attiva (default)/disattiva il pannello strumenti.

- `--enable-random-buildings, --disable-random-building`

  Abilita/disabilita (default) la visualizzazione di edifici casuali. Se attivata, questa opzione richiede molta memoria.

- `--enable-random-objects`, `--disable-random-objects`

  Abilita (default)/disabilita la visualizzazione di oggetti casuali negli scenari.

- `--enable-random-vegetation`, `--disable-random-vegetation`

  Attiva (default)/disattiva la visualizzazione di vegetazione casuale come alberi. Richiede una scheda grafica che supporti Shader GLSL (alcune schede grafiche meno recenti o meno potenti non lo fanno).

- `--enable-rembrandt`, `--disable-rembrandt`

  Abilita/disabilita (impostazione predefinita) una funzione sperimentale che include una maggiore illuminazione e ombre in tempo reale.

- `--enable-skyblend`, `--disable-skyblend`

  Attiva (default)/disabilita l'appannamento/foschia.

- `--enable-specular-highlight`, `--disable-specular-highlight`

  Attiva (default)/disabilita la visualizzazione delle luci speculari.

- `--enable-splash-screen`, `--disable-splash-screen`

  Attiva/disattiva (default) il logo rotante della 3DFX quando la scheda acceleratrice viene inizializzata (solo per 3DFX).

- `--enable-textures`, `--disable-textures`

  Attiva (default)/disabilita l'uso di texture.

- `--enable-wireframe`, `--disable-wireframe`

  Abilita/disabilita (default) la visualizzazione dei wireframe. Se volete sapere come sono fatti internamente gli scenari di *FlightGear*, provate ad attivare questa opzione!

- `--fog-disable`, `--fog-fastest`, `--fog-nicest`

  mposta il livello di visualizzazione della nebbia. Per ridurre gli sforzi del rendering, le zone lontane spariscono nella nebbia per impostazione predefinita. Se si disattiva la nebbia (`--fog-disable`) si vedrà più lontano, ma diminuiranno i frame rate. Utilizzando `--fog-fastest` si visualizzerà una nebbia meno realistica, per aumentare il frame rate. L'impostazione predefinita è `--fog-nicest` (la nebbia più realistica).

- `--fov=`*gradi*

  Imposta il campo visivo in gradi. L'impostazione predefinita è 55.0.

- `--materials-file=`*file*

  Indica i file dati utilizzati per il rendering dei paesaggi. La configurazione di default è: `Materials/regions/materials.xml`.

- `--geometry=`*WWWxHHH*

  Definisce la risoluzione della finestra/schermo. Ad esempio `--geometry=1024x768`..

- `--shading-smooth, --shading-flat`

  Dice al simulatore se utilizzare l'ombreggiatura uniforme (default), o l'ombreggiatura piatta che è più veloce ma meno bella.

- `--texture-filtering=`*N*

  Configura il filtro anisotropico della texture. I valori disponibili sono: 1 (impostazione predefinita), 2, 4, 8 o 16.

- `--view-offset=`*xxx*

  Consente di direzionare la visualizzazione predefinita in avanti rispetto ad un angolo di 0. I valori possibili sono `LEFT`, `RIGHT`, `CENTER`, o un numero specifico di gradi. Utile per la visualizzazione multi-finestra.

4.4.9 Opzioni HUD

- `--enable-anti-alias-hud, --disable-anti-alias-hud`

  Controlla se l'HUD (Head Up Display) debba venire avviato in modalità anti-alias.

- `--enable-hud, --disable-hud`

  Controlla se debba venire visualizzato l'HUD o meno. Il valore predefinito è `--disable-hud`

- `--enable-hud-3d, --disable-hud-3d`

  Controlla se debba venire visualizzato l'HUD o meno. Il valore predefinito è `--disable-hud-3d`

- `--hud-culled, --hud-tris`

  Visualizza la percentuale di triangoli utilizzati nell'HUD. Principalmente di interesse per gli sviluppatori di grafica.

4.4.10 Opzioni di sistema degli aeromobili

- `--adf=`*[radiale:]frequenza*

  Imposta la frequenza ADF e la radiale.

- `--com1=`*frequenza*, `--com2=`*frequenza*

  Imposta la frequenza radio COM1/COM2.

- `--dme=`*nav1|nav2|frequenza*

  Imposta il DME per NAV1, NAV2, o per una frequenza/radiale specifica.

- `--failure=`*sistema*

  Guasta un sistema specifico dell'aeromobile. I sistemi validi sono: `pitot`, `static`, `vacuum`, `electrical`. Usare più volte il comando per guastare più sistemi.

- `--nav1=`*[radiale:]frequenza*, `--nav2=`*[radiale:]frequenza*

  Imposta una determinata frequenza radio/radiale per il NAV1/NAV2.

4.4.11 Opzioni di tempo

- `--enable-clock-freeze`, `--disable-clock-freeze`

  Controlla se il tempo debba avanzare normalmente o essere fermo (congelato).

- `--start-date-gmt=`*yyyy:mm:dd:hh:mm:ss*, `--start-date-lat=`*yyyy:mm:dd:hh:mm:ss* `--start-date-sys=`*yyyy:mm:dd:hh:mm:ss*

  Indicano l'esatta ora di partenza/data. Le tre funzioni differiscono tra loro perchè la prima prende come riferimento il Greenwich Mean Time, la seconda usa l'ora locale del volo virtuale, e la terza l'ora locale del computer. Incompatibile con `--time-match-local`, `--time-match-real`.

- `--time-match-local`, `--time-match-real`

  Quando si utilizza l'opzione --time-match-real(default), la data del simulatore viene letta dal clock del sistema, e viene utilizzata così com'è. Quando il volo virtuale è ambientato nello stesso fuso orario in cui si trova il computer, questo può essere affidabile, perché gli orologi sono sincronizzati. Tuttavia, quando si vola in una parte diversa del mondo, potrebbe non essere il caso, perché c'è un numero di ore di differenza tra la posizione del computer e la posizione del proprio volo virtuale.

  L'opzione --time-match-local tsi occupa di questo calcolando la differenza del fuso orario tra il reale fuso orario del mondo e la posizione del volo virtuale, rendendo così i due orari sincronizzati.

  Incompatibile con `--start-date-gmt`, `--start-date-lat`, `--start-date-sys`.

- `--time-offset=`*[+-]hh:mm:ss*

  Questo comando consente di specificare manualmente la differenza tra l'orario del proprio computer e quello desiderato per il volo virtuale.

- `--timeofday=`*param*

  Imposta l'ora del giorno. I parametri validi sono: `real` (ora reale), `dawn` (alba), `morning` (mattina), `noon` (mezzogiorno), `afternoon` (pomeriggio), `dusk` (tramonto), `evening` (sera) e `midnight` (mezzanotte).

4.4.12 Opzioni di rete

- `--multiplay=`*dir,Hz,host,porta*, `--callsign=`*NOME*

  Imposta le opzioni per il multigiocatore (Vedi sezione 6.1).

- `--httpd=`*porta*, `--telnet=`*port*

  Abilita un server http o un server telnet sulla porta specificata per consentire l'accesso alla struttura di proprietà.

- `--jpg-httpd=`*porta*

  Abilita l'acquisizione dello schermo da parte del server http montato sulla porta specificata.

- `--proxy=`*[user:password@]host:porta*

  Imposta il proxy da utilizzare per le connessioni.

4.4.13 Opzioni percorso/tappe

- `--wp=`*ID[@alt]*

  Permette di specificare un waypoint (punto di passaggio) per il pilota automatico, è possibile specificare più waypoints (e quindi tracciare un percorso) tramite più istanze di questo comando.

- `--flight-plan=`*[file]*

  Questo è il comando più comodo da usare per indicare al programma il proprio piano di volo se si ha già un file contenente le diverse tappe.

4.4.14 Opzioni IO

NB: Queste opzioni sono piuttosto orientate all'utente avanzato che sa quello che sta facendo.

Descrizioni più dettagliate dei vari parametri IO possono essere trovate nel file README.IO presente all'interno della directory Docs nella cartella d'installazione di *FlightGear*.

- `--atlas=`*parametri*

  Avvia la connessione utilizzando il protocollo Atlas (utilizzato da Atlas e TerraSync).

- `--atcsim=`*parametri*

  Apre la connessione utilizzando il protocollo ATC Sim (atc610x).

- `--AV400=`*parametri*

  Avvia il collegamento usando un Garmin serie 196/296 GPS.

- `--AV400Sim`=*parametri*

  Avvia il collegamento usando un Garmin serie 400 GPS.

- `--generic`=*parametri*

  Apre la connessione utilizzando il protocollo generico (definito da un file XML).

- `--garmin`=*parametri*

  Apre la connessione utilizzando il protocollo GPS Garmin.

- `--joyclient`=*parametri*

  Apre il collegamento ad un joystick Agwagon.

- `--jsclient`=*parametri*

  Apre il collegamento ad un joystick remoto.

- `--native-ctrls`=*parametri*

  Apre la connessione utilizzando il protocollo FG Native Controls.

- `--native-fdm`=*parametri*

  Apre la connessione utilizzando il protocollo FG Native FDM.

- `--native-gui`=*parametri*

  Apre la connessione utilizzando il protocollo FG Native GUI.

- `--native`=*parametri*

  Apre la connessione utilizzando il protocollo FG Native.

- `--nmea`=*parametri*

  Apre la connessione utilizzando il protocollo NMEA.

- `--opengc`=*parametri*

  Apre la connessione utilizzando il protocollo OpenGC.

- `--props`=*parametri*

  Apre la connessione utilizzando il gestore di proprietà interattivo.

- `--pve`=*parametri*

  Apre la connessione utilizzando il protocollo PVE.

- `--ray`=*parametri*

  Apre la connessione utilizzando il protocollo RayWoodworth motion chair.

- `--rul`=*parametri*

  Apre la connessione utilizzando il protocollo RUL.

4.4.15 Opzioni di debug

NB: Queste opzioni sono piuttosto orientate all'utente avanzato che sa quello che sta facendo.

- `--enable-fpe`

  Abilita l'interruzione del simulatore al verificarsi di un errore di virgola mobile (Exception Floating Point).

- `--fgviewer`

  Invece di caricare l'intera simulazione, caricare una visualizzazione leggera OSG. Utile per controllare i modelli di aeromobili.

- `--log-level=`*livello*

  Imposta il livello di registrazione dei log. I valori validi sono: `bulk`, `debug`, `info`, `warn`, `alert`.

- `--prop:[tip:]nome=valore`

  Assegna un determinato valore ad una proprietà. Si può opzionalmente specificare il tipo di proprietà (`double`, `string`, `boolean`).

  Esempio: `--prop:/engines/engine[0]/running=true` starts the simulator with running engines.

  Altro esempio:

  ```
  --aircraft=c172p
  --prop:/consumables/fuels/tank[0]/level-gal=10
  --prop:/consumables/fuels/tank[1]/level-gal=10
  ```

  (riempie il Cessna di carburante per un breve volo).

- `--trace-read=`*parametri*

  Traccia la legge per una proprietà, sono ammesse più istanze.

- `--trace-write=`*parametri*

  Traccia le scritture di una proprietà, sono ammesse più istanze.

4.5 Supporto per il joystick

Riuscite a immaginare un pilota nel suo Cessna che lo controlla soltanto con una tastiera? Per ottenere la giusta sensazione di volo servono un joystick e una pedaliera!

FlightGear ha integrato il supporto per il joystick, che rileva automaticamente qualsiasi joystick o pedaliera collegati. Basta collegare la periferica e avviare il simulatore.

Si può vedere la configurazione per l'utilizzo del joystick andando nel me-
nù Guida–>Configurazione Joystick. Questa finestra mostra il nome del vostro
joystick, e la funzione abbinata a ciascun pulsante/asse di controllo. è possibile
premere un tasto o muovere il joystick per vedere esattamente la sua funzione e
modificarla. In caso di modifiche, la configurazione ha effetto immediato e sarà
salvata per tutti i prossimi voli.

Se si dispone di un joystick comune, ci sono molte probabilità che qualcuno
abbia già istituito una configurazione specifica di FlightGear per esso, e si può
semplicemente iniziare a volare!.

Capitolo 5

In volo: tutto su strumenti, tasti e menù

La seguente è una descrizione dei principali sistemi di controllo del programma e di istruzioni riguardanti come pilotare gli aerei. Si presuppone che il lettore abbia già familiarità con il volo, possibilmente da esperienze in altri simulatori. Se siete completamente nuovi dell'argomento, le esercitazioni nella sezione 7 sono la risorsa migliore per imparare a volare con *FlightGear*.

Una breve opuscolo pronto per essere stampato che mostra i tasti e le cose più importanti è disponibile all'indirizzo

http://www.flightgear.org/Docs/FGShortRef.pdf.

Inoltre un riferimento alla maggior parte dei comandi della tastiera si trova nel menù "Guida" all'interno del simulatore.

5.1 Avviamento del motore

A seconda del tipo di aeromobile, potrebbe essere necessario avviare il motore(i) prima di poter andare in volo. Le istruzioni che seguono sono generiche. Verificare le specifiche tecniche o guardare tutorial riguardo l'aereo in questione per istruzioni più precise.

Una volta avviato il motore, si dovrebbe verificare se i freni di stazionamento siano attivi. Se così fosse, premere il tasto 'B' per liberarli.

5.1.1 Aerei a pistone

Per gli aeromobili con motore a pistoni, i magneti sono controllati tramite i tasti "{" e "}".

Sulla maggior parte degli aerei, si può controllare il motorino d'avviamento con il tasto "s". Negli aerei con più motori è possibile scegliere quale motore controllare. Utilizzare "˜" per selezionare tutti i motori contemporaneamente.

La maggior parte dei magneti hanno 4 posizioni: "OFF", "magnete sinistro", "magnete destro" e "ENTRAMBI". Quindi, per avviare il motore selezionato, premere il tasto "}" tre volte e poi tenere premuto "s".

Si noti che la procedura di partenza per i potenti aerei da combattimento della Seconda Guerra Mondiale è spesso più complessa. Vedere la guida dell'aeromobile per maggiori dettagli.

5.1.2   Aerei a turboelica

Avviare un motore a turboelica generalmente richiede semplicemente lo spostamento della leva di avviamento da "Off" a "Idle", usando il tasto "m".

5.1.3   Aerei Jet

L'avvio di un aereo a reazione è molto più complesso, ed i controlli variano solitamente tra i diversi aeromobili.

1. Attivare l'afflusso del carburante

2. Coinvolgere il motorino di avviamento

3. Una volta raggiunta la pressione dei motori di circa 5% N1, impostare le pompe del carburante ad OFF

4. Disinserire il motorino di avviamento quando il motore ha raggiunto la velocità operativa.

5.2   Controlli da tastiera

Sebbene siano ampiamente supportati joystick e pedaliere, si può volare con *Flight-Gear* utilizzando anche unicamente la tastiera (tanto comunque non si potrebbe farne a meno) in combinazione possibilmente con un mouse, come descritto di seguito. Le associazioni dei tasti alle funzioni del simulatore sono liberamente modificabili dall'utente. è possibile controllare e modificare queste impostazioni tramite il file ASCII leggibile `keyboard.xml` che si trova nella directory principale di *FlightGear*. Anche se modificare questo file non è forse la miglior idea per i principianti, gli utenti più avanzati potranno trovare utile cambiare le associazioni dei tasti alle varie funzioni secondo i loro desideri, ad esempio, per abbinare altri simulatori.

5.2.1   Controlli per gli aeromobili

Per avere il pieno controllo dell'aereo durante il volo utilizzando la tastiera è necessario assicurarsi che il BLOC NUM sia attivo, e la finestra di FlightGear sia selezionata e a fuoco. I seguenti tasti del tastierino numerico controllano le superfici primarie degli aeromobili.

Pulsante/i	Azione
9 / 3	Manetta (Throttle)
4 / 6	Alettoni
8 / 2	Elevatore (timone di coda)
0 / Invio	Timone di direzione
5	Centra alettoni, timone di coda e di direzione
7 / 1	Regola il trim trim

Table 1: *Superfici primarie degli aeromobili*

I seguenti tasti controllano i motori.

Pulsante/i	Azione
!	Seleziona il 1° motore
@	Seleziona il 2° motore
#	Seleziona il 3° motore
$	Seleziona il 4° motore
~	Seleziona tutti i motori
{	Diminuisce la forza dei magneti sui motori selezionati
}	Aumenta la forza dei magneti sui motori selezionati
s	Avvia i(l) motore/i selezionato/i
M / m	Impoverisce/Arricchisce la miscela del motore selezionato
N / n	Diminuisce/Aumenta il passo dell'elica del motore selezionato

Table 2: *Engine control keys*

I seguenti, invece, controllano i sistemi secondari del velivolo:

Pulsante/i	Azione
b	Applica tutti i freni (tenere premuto)
, / .	Applica/Toglie il freno di sinistra/destra
l	Mette/Toglie il blocco delle ruote di coda
B	Toglie/Mette i freni di parcheggio
g/G	Alza/Abbassa il carrello d'atterraggio
Space	Tenendolo premuto si parla usando FGCom (PTT)
- / _	Comandano la chat scritta
[/]	Ritrae/Estende i flaps
j / k	Ritrae/Estende i deflettori
Ctrl-B	Applica/Toglie gli aerofreni

Table 3: *controllano i sistemi secondari del velivolo*

5.2.2 Controlli del simulatore

Per cambiare la direzione della visuale, è necessario disattivare BLOC NUM. I controlli disponibili sono i seguenti:

Tasti del Tastierino Numerico	Direzione Visuale
Shift-8	Avanti
Shift-7	Sinistra/Avanti
Shift-4	Sinistra
Shift-1	Sinistra/Indietro
Shift-2	Indietro
Shift-3	Destra/Indietro
Shift-6	Destra
Shift-9	Destra/Avanti

Table 4: *View directions*

Inoltre, i seguenti tasti consentono di controllare la visualizzazione:

Pulsante/i	Azione
P	Attiva/Disattiva il pannello strumenti
c	Cabina di pilotaggio 2D/3D (se disponibili entrambi)
S	Cambia lo stile del pannello (Totale/ridotto)
Ctrl-C	Evidenzia tutti i punti cliccabili del simulatore
h	Mette/Toglie l'hud
H	Controlla la luminosità dell'hud
i / I	Diminuisce/Aumenta le dimensioni dell'hud
x / X	Aumenta/Diminuisce lo zoom
v / V	Cambia la visuale (visuale successiva/precedente)
Ctrl-V	Torna subito alla visuale pilota
z / Z	Incrementa/Decrementa la visibilità (nebbia)
F10	Visualizza/Nasconde i menù
Shift-F10	Attiva/Disattiva la modalità a schermo intero

Table 5: *Display options*

Pulsante/i	Azione
p	Mette in pausa il simulatore
a / A	Aumenta/Diminuisce la velocità della simulazione
t / T	Aumenta/Diminuisce la velocità del tempo nel simulatore (orologio)
Ctrl-R	Replay istantaneo
F3	Salva una foto dello schermo (screenshot)
ESC	Esce dal programma
Shift - ESC	Riavvia la simulazione

Table 6: *General simulator controls.*

5.2.3   Controlli del pilota automatico

FlightGear supporta due tipi di pilota automatico: uno generico che funziona con tutti gli aeromobili (anche quelli che normalmente non hanno un pilota automatico), e il pilota automatico specifico dell'aeromobile, che è controllato dall'interno della cabina di guida.

L'autopilota generico viene controllato tramite i seguenti tasti (non del tastierino numerico):

Pulsante/i	Azione
Backspace	Attiva/Disattiva il pilota automatico
Ctrl-A	Attiva/Disattiva il mantenimento di quota automatico
Ctrl-G	Attiva/Disattiva il mantenimento del sentiero di discesa (NAV 1)
Ctrl-H	Attiva/Disattiva la modalità di attesa ()
Ctrl-N	Attiva/Disattiva il blocco NAV 1
Ctrl-S	Attiva/Disattiva il
Ctrl-T	Attiva/Disattiva il blocco AGL
Ctrl-U	Sale di 1000 piedi rispetto all'altitudine attuale (emergenza)
F6	Attiva/Disattiva il mantenimento automatico della rotta
F11	Apre la finestra di dialogo delle impostazioni del pilota automatico
8 / 2	Regola l'altitudine impostata nel pilota automatico
4 / 6	Regola la rotta impostata nel pilota automatico
9 / 3	Regola la velocità impostata nel pilota automatico

Tab. 7: *Autopilot controls.*

La combinazione di tasti Ctrl + T è particolarmente interessante in quanto fa sì che l'aereo si comporti come un missile cruise, e segua il terreno. Ctrl + U potrebbe essere utile nel caso in ci si stia per schiantare.

5.3 Controlli del mouse

Così come per selezionare le voci dei menu e cliccare sui controlli nell'abitacolo, il mouse può essere utilizzato per una vasta gamma di altre funzioni importanti in FlightGear. Ci sono tre modalità di utilizzo del mouse: Normale (impostazione predefinita), di controllo e di visualizzazione. è possibile cambiare modalità usando il Tab.

5.3.1 Modalità normale

In modalità normale, è possibile controllare i menù e i comandi del pannello. Questa modalità è indicata dal normale cursore del mouse (solitamente una freccia bianca).

Per girare un interruttore o tirare una leva, è sufficiente fare clic su di esso/a con il tasto sinistro o centrale del mouse (la rotellina).

Per girare una manopola di una radio o per premere un pedale, clicca sul lato sinistro dell'oggetto per diminuire il valore, e sul lato destro per aumentare il valore. Cliccando con il pulsante sinistro del mouse si può cambiare valore molto velocemente, mentre invece il tasto destro è adibito ai piccoli aggiustamenti del valore. Alcuni controlli, come la radio, supportano anche l'utilizzo della rotellina del mouse.

Premendo Ctrl-C si evidenziano tutti i punti cliccabili del velivolo.

Alcuni comandi possono essere azionati soltanto con la rotellina del mouse (ad esempio la leva del carrello di atterraggio).

5.3.2   Modalità di controllo

In questa modalità è possibile controllare la cloche dell'aeromobile muovendo il mouse.

Questa modalità è indicata dal puntatore del mouse a forma di croce.

Spostando il mouse a sinistra o a destra si controllano gli alettoni del velivolo e di conseguenza si eseguono delle virate. Spostando il mouse in avanti o indietro, invece, si controlla la direzione verticale del muso dell'aereo e quindi l'altitudine del velivolo.

Tenendo premuto il tasto sinistro del mouse si cambia il comportamento del simulatore in modo che spostando il mouse a sinistra/destra si controlli il timone di coda. Tenendo premuto il tasto centrale del mouse e spostandolo avanti e indietro si può controllare la manetta.

Infine, la rotella di scorrimento può essere utilizzata per impostare il trim.

Questa modalità è particolarmente utile se non si dispone di un joystick, in quanto fornisce ugualmente un comodo controllo del velivolo. Se si intende utilizzare il mouse per controllare l'aereo regolarmente, si consiglia di attivare l'auto-coordinamento (un sistema che collega gli alettoni al timone). Questo può essere fatto utilizzando `--enable-auto-coordination` da riga di comando, oppure spuntando l'opzione "auto-coordinamento" nel programma di avvio.

5.3.3   Modalità di visualizzazione

In modalità di visualizzazione ci si può guardare intorno usando il mouse. Questa modalità è indicata dal cursore del mouse a forma di una freccia a due punte.

Ciò è particolarmente utile per osservare le varie parti della cabina di pilotaggio o per vedere il mondo circostante l'aereo. La rotella di scorrimento può essere utilizzata per zoomare. Facendo clic col pulsante sinistro del mouse si ripristina la visuale iniziale.

Tenendo premuto il tasto centrale e spostando il mouse è possibile spostare il punto di vista stesso più a sinistra/destra/su/giù. Muovendo il mouse premendo contemporaneamente la rotellina e il tasto Ctrl si può spostare il punto di vista in avanti e indietro.

5.4   Voci del menù

La barra dei menù fornisce l'accesso a una varietà di opzioni per il simulatore e per l'aereo. Molti aerei hanno delle proprie voci aggiunte ai menù standard, spesso per avviare automaticamente i motori (autostart) o per gestire azioni speciali. Queste possono essere trovate in fondo alla barra dei menù.

Per visualizzare o nascondere la barra dei menù, premere F10. è anche possibile visualizzare automaticamente il menù muovendo il mouse nella parte superiore dello schermo.

La barra dei menù fornisce i seguenti menù e sottomenù:

- **File**

  - **Reset (Shift-Esc):** Ripristina il volo alla posizione di partenza. Opzione utile se ci si perde o se va storto qualcosa.

  - **Load Flight Recorder Tape (Shift-F1):** Carica un volo salvato precedentemente assieme a tutte le sue condizioni (meteo, guasti, rotta ecc.)

  - **Save Flight Recorder Tape (Shift-F2):** Salva il volo attuale.

  - **Screenshot (F3):** Salva una foto allo schermo nel formato fgfs-screen-XXX.jpg

  - **Cartella screenshot:** Consente di impostare la cartella dove saranno salvati gli screenshot.

  - **Configurazione audio:** Configura il volume dei vari canali audio.

  - **Input Configuration:** Configura il comportamento del mouse.

  - **Download scenari:** Configura il download automatico degli scenari da Internet utilizzando la funzione *TerraSync*.

  - **Aircraft Center (Experimental)** allows you to download and install aircraft from within the simulator. Experimental.

  - **Esci (Esc):** Esce dal programma.

- **Visuale**

  - **Schermo intero (Shift-F10):** Visualizza il simulatore in una finestra o a schermo intero.

  - **Opzioni rendering:** Configura varie caratteristiche grafiche. Questo permette di impostare effetti speciali, come ombre, nuvole 3D e riflessi speculari. Per raggiungere un buon equilibrio, si consiglia di attivare l'opzione Mostra Frame Rate nel menu Opzioni di visualizzazione, che mostrerà il frame-rate corrente in fotogrammi al secondo in basso a destra dello schermo. Il numero minimo consigliato di frame-rate è di 20fps. Il frame-rate è influenzato dalle caratteristiche grafiche abilitate, dalla visibilità corrente (impostabile da Z/z), dal numero di oggetti in vista e dal loro livello di dettaglio (LOD).

  - **Opzioni visualizzazione:** Dice al simulatore cosa visualizzare e come, inoltre è possibile gestire i pannelli 3D/2D, i frame rate e decidere se visualizzare o meno la chat.

- **Opzioni visualizzazione cockpit:** Configura la visuale all'interno della cabina di guida, il movimento della testa del pilota pilota, il black-out a causa della alta forza G, e il redout a causa della forza G negativa.

- **Livello di dettaglio:** Imposta i valori dei diversi livelli di dettaglio della texture e di tutti gli oggetti presenti nel simulatore.

- **Posizione pilota:** Visualizza e permette di modificare i dettagli dell'angolo della visuale corrente. Costituisce un'alternativa alle modifiche del punto di vista effettuate con il mouse (vedi sopra).

- **Proprietà dell'HUD:** Configura le impostazioni dell'Head Up Display (HUD), come la trasparenza, la luminosità e l'attivazione dell'anti-alias.

- **Visualizza l'angolo di discesa:** Visualizza un tunnel virtuale per guidare l'utente verso la pista. Utile se si hanno problemi a impostare l'approccio per l'atterraggio.

- **Replay istantaneo (Ctrl-R):** Controlla le funzionalità del replay istantaneo, un ottimo strumento per rivedere le proprie manovre in volo.

- **Earthview Orbital Rendering** controls the earthview orbital rendering based on the NASA Visible Earth image collection

- **Opzioni visualizzazione stereoscopica:** Configura la visualizzazione permettendo di modificare, ad esempio, la distanza degli occhi del pilota.

- **Posizione**

  - **Posiziona l'aereo in volo:** Posiziona l'aeromobile in aria. è necessario selezionare un punto noto, ad esempio un aeroporto, una stazione VOR, o delle coordinate, ed alcuni dati aggiuntivi relativi a quel punto, ad esempio la distanza, la direzione, l'altitudine. è anche possibile impostare la velocità iniziale e la rotta. Questo strumento è utile per praticare approcci o per trovarsi già in aria pronti per volare.

  - **Seleziona un aeroporto dalla lista:** Apre una finestra di dialogo che permette di posizionare il velivolo su una pista o in un parcheggio di un aeroporto.

  - **Altitudine casuale:** Posiziona l'aereo ad altitudine, rotta e velocità casuali.

  - **Posizione della torre:** Permette di modificare la posizione della torre dell'aeroporto. Utilizzato per la visuale dalla torre di controllo (Tower View).

- **Pilota automatico** Questo menù controlla il pilota automatico generico interno del simulatore. Alcuni aerei hanno anche il proprio pilota automatico configurabile tramite l'apposito pannello.

- **Settaggio Pilota Automatico (F11):** Configura il pilota automatico dell'aeromobile. è possibile impostare il pilota automatico in una varietà di modi diversi - dal semplice mantenere la stabilità del velivolo, al seguire un segnale ILS.
- **Route Manager:** Imposta l'elenco delle tappe (waypoint) per l'autopilota. Questi possono essere aeroporti o coordinate. Il nome, la distanza e il durata del percorso per il waypoint corrente possono essere visualizzati nell'HUD.
- **Waypoint precedente:** Seleziona il Waypoint precedente da una lista.
- **Waypoint successivo:** Seleziona il Waypoint successivo da una lista.

- **Ambiente**

  - **Meteo:** Consente di impostare il meteo corrente, selezionare uno scenario meteo, o utilizzare il tempo riportato via METAR dalla stazione meteo del riferimento più vicino al velivolo (di solito un aeroporto).
  - **Impostazioni d'ambiente:** Consente di scegliere quale stagione usare nel simulatore (estate o inverno), e le condizioni del terreno come il livello della neve o la polvere.
  - **Configura orario:** Consente di impostare l'ora corrente nel simulatore, di accelerare la simulazione e di cambiare la velocità con cui passa il tempo nel simulatore (orologio). Visualizza anche l'ora UTC e l'ora locale.
  - **Configura incendi:** Configura gli incendi del simulatore. Utile per simulare una missione di soccorso con aerei attrezzati per lo spegnimento dei fuochi.

- **Equipaggiamento**

  - **Mappa:** Visualizza una mappa in movimento, mostrando aeroporti, fari, stazioni radio, montagne e traffico aereo vicini al proprio velivolo.
  - **Mappa (Canvas):** displays an alternative moving map using Canvas
  - **Cronometro:** Visualizza un semplice cronometro. Utile per gli avvicinamenti strumentali. approaches.
  - **Carburante e carico:** Consente di impostare i livelli del carburante e il peso del carico corrente all'interno dell'aeromobile. Disponibile solo su alcuni aerei.
  - **Configura radio (F12):** Imposta le frequenze e i radiali utilizzati dalle radio e dalle apparecchiature di navigazione.
  - **Configura GPS:** Configura i waypoint e come devono venire visualizzate le informazioni del GPS.

- **Configura Strumenti di bordo:** Consente di impostare la pressione dell'altimetro e la rotta per il computer di bordo.
- **Guasti casuali:** Configura i guasti casuali dei vari sistemi e strumenti aeronautici, consentendo di impostare un tempo medio tra i guasti (MTBF) o dei cicli periodici esatti (MCBF).
- **Guasti di sistema:** Configura i guasti del sistema dell'aereo, come ad esempio l'apparato di pressurizzazione o i motori.
- **Guasti degli strumenti di bordo:** Configura i guasti degli strumenti di bordo, come ad esempio il GPS o l'altimetro.

- **AI**

  - **Traffic and Scenario Settings** configures the active AI scenarios. Note that this will only take effect after the simulator is re-started.
  - **ATC Services in Range** displays the airport communications frequencies for nearby airports.
  - **Wingman Controls** allows you to control AI wingmen (depending on aircraft).
  - **Tanker Controls** allows you to dynamically create an air-to-air refueling tanker, if your aircraft supports it. See Section 6.8 for further details.
  - **Carrier Controls** allows you to control an AI aircraft carrier.
  - **Jetway Settings** allows you to control jetways on some airports.

- **Multiplayer**

  - **Multipler Settings** allows you to enable Multiplayer by setting a callsign and server.
  - **FGCom Settings** allows you to configure voice communications with other Multiplayer users.
  - **Chat Dialog** allows you to chat with other aircraft in the multi-player environment.
  - **Chat Menu (-)** allows you to send common chat messages to other aircraft or ATC in the multi-player environment. Some menus contain sub-menus of options.
  - **Pilot List** displays list of the other multi-player pilots within range, along with their distance, heading and altitude.
  - **MPCarrier Selection** displays a list of the available MPCarriers.

- **Debug** menu contains various options outside the scope of this guide.

- **Help**

    - **Help** opens the help system in a browser window.

    - **Aircraft Help** displays information specific to the aircraft.

    - **Aircraft Checklists** displays specific checklists for this aircraft, if available.

    - **Common Aircraft Keys** lists the basic keys for controlling the aircraft.

    - **Basic Simulator Keys** lists the basic keys for the controlling the simulator.

    - **Joystick Configuration** allows you to configure your joystick from within the simulator, including axes and button assignments.

    - **Tutorials** allows you to start an in-simulator tutorial for the current aircraft. This is only available on some aircraft. See Tutorials below for details.

    - **About** displays information about this version of FlightGear.

5.5 The Instrument Panel

Fig. 6: *The 3D cockpit of the Cessna 172.*

Aircraft within *FlightGear* can have both a 2-dimensional instrument panel and a 3-dimensional cockpit. The 3-dimensional cockpit provides a much more realistic pilot-eye view, but can be difficult to read with small monitors.

The default Cessna 172P (c172p) has both a 3-dimensional and 2-dimensional cockpit. The 3-dimensional cockpit is activated by default when you start *Flight-Gear*, but you can overlay the 2-dimensional instrument panel by selecting `View->Display Options->Show 2D Panel` from the menu, or pressing the "P" key.

All panel levers and knobs can be operated with the mouse. To change a control, just click with the left/middle mouse button on the corresponding knob/lever. For controls that have a range of positions, use the middle mouse button for larger adjustments. In general, clicking on the right side of a control will increase the value, while clicking the left side of the control will decrease the value.

Some instruments (particularly radios) also support use of a mouse scroll-wheel to change values. Other controls (such as throttle) can also be dragged using the left mouse button.

5.6   The Head Up Display

FlightGear also provides a HUD (**H**ead **U**p **D**isplay) . HUDs are generally found in military aircraft and some very advanced jets. However, *FlightGear* also allows you to use a HUD on many GA aircraft. To activate the HUD, press 'h'.

The HUD shown in Fig. 7 displays all main flight parameters of the plane. In the center you find the pitch indicator (in degrees) with the aileron indicator above and the rudder indicator below. A corresponding scale for the elevator can be found to the left of the pitch scale along with a pitch trim indicator. On the bottom there is a simple turn indicator.

There are two scales at the extreme left: The inner one displays the speed (in kts) while the outer one indicates position of the throttle. The two scales on the extreme right display your height - the left one shows the height above ground while the right of it displays height above sea-level, both being displayed in feet.

Besides this, the HUD delivers some additions information. On the upper left you will find date and time, along with your current position, in latitude and longitude.

You can change color of the **HUD** using the "H" or "'h" key. Pressing the toggle "i/I" minimizes/maximizes the HUD.
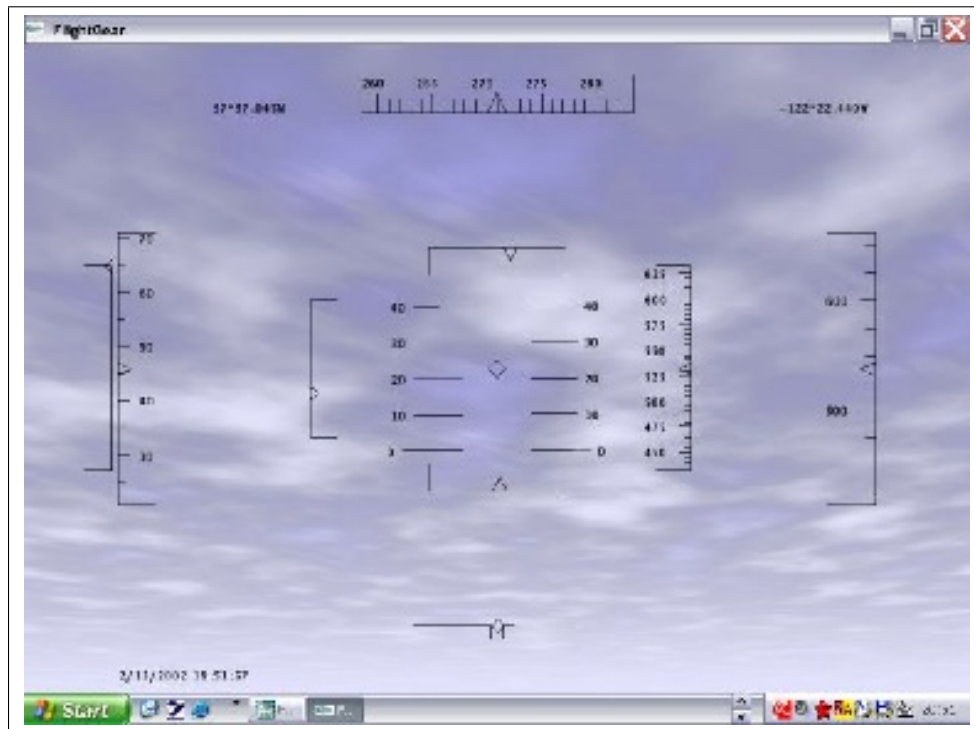
Fig. 7: *The HUD, or Head Up Display.*

Chapter 6

Features

FlightGear contains many special features, some of which are not obvious to the new user. This section describes how to enable and make use of some of the more advanced features.

Many of the features are under constant development, so the information here may not be completely up-to-date. For the very latest information (and new features), see the *FlightGear* Wiki, available from http://wiki.flightgear.org/

6.1 Multiplayer

FlightGear supports a multiplayer environment, allowing you to share the air with other flight-simmers. For server details and to see who is online (and where they are flying), have a look at the excellent multiplayer map, available from http://mpmap02.flightgear.org

Click on the 'server' tab to see a list of multiplayer servers.

6.1.1 Quick Start

You can connect to the MP environment from the MP Settings dialog under the Multiplayer menu. Simply select the server closest to you from the list, enter a callsign (which will be seen by other players), and click "Connect".

To see a list of other pilots are in the area, select Pilot List from the Multiplayer menu.

All the standard MP servers are interconnected, so there is no need to be on the same server as people you are flying with.

6.1.2 Other Methods

If you are connecting to a non-standard server, or the above method does not work, you can also connect using the methods below.

Using the FlightGear Launcher

The final screen of the FlightGear Launcher has a section for Multiplayer. Simply select the checkbox, enter the hostname and port number you noted above and choose a callsign to identify yourself. Your callsign can be up to 7 characters in length. You must also check The AI models checkbox under Features to make other aircraft visible.

Using the Command Line

The basic arguments to pass to fgfs for multiplayer are these:

```
--multiplay=out,10,<server>,<portnumber>
--multiplay=in,10,<client>,<portnumber>
--callsign=<anything>
--enable-ai-models
```

Where

1. <portnumber> is the TCP port number of the server e.g. 5000.

2. <server> is the name of the multiplayer server e.g. mpserver01.flightgear.org.

3. <client> is the name of your computer, or the IP address ip address of the network interface being used by FG to connect to the server - even if that's a local 192.168 type address. e.g. 192.168.0.1

4. <callsign> is the call sign to identify yourself, up to 7 characters, e.g. N-FGFS.

Once the simulator has loaded, you should see yourself displayed on the map. If you don't, check the console for error messages and see the Troubleshooting section below.

6.1.3   Troubleshooting

To get multiplayer to work, we need information about the IP address of our computer and the ability to communicate with the server. How to get this information depends on your configuration and is described below.

Those using a USB modem to connect to the Internet

First of all, you need to know the IP address of the network interface you're going to be running FG multiplayer over. If your Internet connection is via an ADSL modem that plugs directly into your computer with a USB connection, you should be able to find your IP address by visiting http://www.whatismyip.com . Please note that this address may very well change every now and again - if MP stops working, check this first.

Those using some kind of Ethernet router to connect to the Internet

Otherwise, your connection is likely via some kind of router that connects to your computer via an RJ-45, or "Ethernet" connector (similar shape to most Western telephone plugs), or by a wireless link. You need to find the IP address of that network interface.

Under Linux, this can be found by logging in as root and typing "ifconfig". You may find more than one interface listed, beginning with "lo" - ignore that one. You should have something like "eth0" or "wlan0" also listed - look through this block of text for "inet addr". This will be followed directly by the number you're looking for, e.g. "inet addr:192.168.0.150"

Under Windows XP, click start, run, and type "cmd". In the terminal window which appears, type "ipconfig" This should show you your IP address - note it down.

With Windows 98, click start, run, and type "winipcfg" to get information about your IP address.

If It Still Doesn't Work

You MUST give your local, behind-the-router IP address for MultiPlayer to work. Trust me on this one!

You should check that your firewall is not causing problems - either turn it off temporarily or add an exception to allow incoming connections on port 5000.

If it's still just not working for you, ask nicely on the FlightGear IRC channel and someone should be able to assist.

6.2 Aircraft Carrier

FlightGear supports carrier operations on the Nimitz, (located near San Fransisco), Vinson, San Antonio, Foch, and Eisenhower. The carriers are equipped with working catapult, arrester wires, elevators, TACAN and FLOLS.

To enable the carrier, you must edit your preferences.xml file in $FG_ROOT using a text editor (e.g. Notepad under Windows). Search for the word "nimitz". You ought to find something that looks like this;

```
<!--<scenario>nimitz_demo</scenario>-->
```

You should remove the "comment" marks so that it looks like this;

```
<scenario>nimitz_demo</scenario>
```

Also ensure that the line above that referring to ai being enabled is set to "true" Save the file and quit the text editor.

6.2.1 Starting on the Carrier

You are now ready to start FlightGear. To position your aircraft on the carrier at startup, use the following command line options:

```
--carrier=Nimitz --aircraft=seahawk
```

Please note the uppercase "N' in "Nimitz'.

If you are using the Windows or OS X launcher to run FG, you should find a text entry box in the gui that allows you to specify command line options, add the above options there.

Note that several FG aircraft are carrier capable, but the seahawk is possibly the easiest to fly to begin with.

6.2.2 Launching from the Catapult

Once FlightGear has started, you should ensure that the parking brakes are off and press and hold "L" to engage the launchbar. You must hold down "L" until the launch bar has engaged. You should notice the aircraft being pulled into alignment with the catapult and see the strops appear and hold down the aircraft. This will only happen if your aircraft is close enough to the correct spot on the catapult; as a rough guide, for the default parking position the seahawk's nose should be rougly level with the deck observation bubble.

To get the carrier into as good a position as possible for launch, select the "ATC/AI" menu, then check the "Turn into wind" box under the "AI Carrier" section. You should now notice the carrier begin to pick up speed and turn into the wind, and naturally the deck may tilt somewhat as it turns. You should wait for this maneuver to finish and the deck to return to level before moving on to the next stage.

Being attached to the catapult, you should spool up the engines to full power, ensure the brakes are off and that all flight controls are in a suitable position for launch (stick held right back with the seahawk.) When ready, press "C" to release the catapult. Your aircraft will be hurled forward off the deck, and you should be able to raise the undercarriage and climb slowly away, being careful to avoid stalling.

6.2.3 Finding the Carrier - TACAN

Actually finding the carrier in a vast expanse of open water can be very difficult, especially if visibility is poor. To assist with this task, Nimitz is equipped with TACAN, which allows a suitably-equipped aircraft (including the Seahawk) to obtain a range and bearing to the carrier. First, you must set the appropriate TACAN channel, 029Y in this case, in the radios dialogue (ctrl-r or choose Equipment/Radio Settings from the FG menubar). You should, if within range, notice the DME instrument show your distance from the carrier, and the ADF instrument

(next to the DME in the seahawk) should indicate a bearing to the carrier. Turn to the indicated heading and you should see the DME dial indicate your closing in on the carrier.

6.2.4 Landing on the Carrier

This is the most difficult part of the operation, as in real life. You might well find Andy Ross' tutorial on operating the A4 Skyhawk useful. It is available from here: http://wiki.flightgear.org/A-4F_Skyhawk_Operations_Manual

Once you have used the TACAN to locate the carrier, you must line up with the rear of the flight deck. As this part of the deck is at an angle to the course of the vessel, you may need to correct your alignment often. Ensure that the aircraft is in the correct configuration for approach (the Help/Aircraft Help menu should contain useful data for your aircraft) and that the gear and the arrestor hook are down.

As you approach you should see, on the left hand side of the deck, a set of brightly coloured lights - called the Fresnel Lens Optical landing System (FLOLS). This indicates your position on the landing glideslope. You will see a horizontal row of green lights, and when approximately on the glideslope, an orange light (known in some circles as the "meatball") approximately in line with the green lights. When approaching correctly, the meatball appears in line with the green lights. If you are high it is above, and when low it is below. If you are very low the meatball turns red. If you fly to keep the meatball aligned you should catch number 3 wire.

Carrier landings are often described as "controlled crashes" and you shouldn't waste your time attempting to flare and place the aircraft gently on the deck like you would with a conventional landing - ensuring that you catch the wires is the main thing.

Immediately your wheels touch the deck, you should open the throttles to full power, in case you have missed the wires and need to "go around" again; the wires will hold the aircraft if you have caught them, even at full power.

If you wish, you can then raise the elevators from the ATC/AI menu, taxi onto one of the elevators, lower it (uncheck the box on the menu) and taxi off into the hangar.

Don't be discouraged if you don't succeed at first - it's not an easy maneouver to master. If after a little practice you find the Seahawk too easy, you could move on to the Seafire for more of a challenge!

6.3 Atlas

Atlas is a "moving map" application for FlightGear. It displays the aircraft in relation to the terrain below, along with airports, navigation aids and radio frequencies.

Further details can be found on the Atlas website:

http://atlas.sourceforge.net

6.4   Multiple Displays

FlightGear supports multiple displays. Using some straightforward XML, you can configure multiple "slave cameras" that are offset from the main view, so you can use multiple monitors to display a single view of the simulator. For example, you can have one display showing the view straight ahead, while two additional displays show the view to either side.

Information on configuring multiple displays can be found in the README.multiscreen file in the docs directory of your *FlightGear* installation.

6.5   Multiple Computer

FlightGear allows you to connect multiple instances of the program using the very flexible I/O subsystem, and display completely different views and controls on different computers. This can be used in combination with the Multiple Display support to create a more sophisticated environment with separate cockpit panel displays and even a separate control station allowing an instructor to fail instruments, change the weather etc.

An example of this is the 747 cockpit project.
http://www.flightgear.org/Projects/747-JW/

6.5.1   Setup

Each instance of *FlightGear* can support a single display. Due to the complexity of the FDM and graphics, *FlightGear* is very processor-intensive, so running multiple instances of *FlightGear* on a single machine is not recommended.

You will therefore need a computer for each view of the simulation you wish to display, including the panel. The computers obviously must be networked and for simplicity should be on the same subnet.

One computer is designated as the master. This computer will run the FDM and be connected to controls such as yokes, joysticks and pedals. As the machine is running the FDM, it usually only displays a simple view, typically the main panel, to maximize performance.

All other computers are designated as slaves. They are purely used for display purposes and receive FDM information from the master.

6.5.2   Basic Configuration

Creating a basic configuration for multiple displays is straightforward. The master computer needs to broadcast the FDM and control information to the slaves. This is done using the following command line options:

```
--native-fdm=socket,out,60,,5505,udp
--native-ctrls=socket,out,60,,5506,udp
```

The slave computers need to listen for the information, and also need to have their own FDMs switched off:

```
--native-fdm=socket,in,60,,5505,udp
--native-ctrls=socket,in,60,,5506,udp
--fdm=null
```

6.5.3 Advanced Configuration

The options listed above will simply show the same view on both machines. You will probably also want to set the following command-line options on both master and slave computers.

```
--enable-game-mode  (full screen for glut systems)
--enable-full-screen (full screen for sdl or windows)
--prop:/sim/menubar/visibility=false (hide menu bar)
--prop:/sim/ai/enabled=false (disable AI ATC)
--prop:/sim/ai-traffic/enabled=false (disable AI planes)
--prop:/sim/rendering/bump-mapping=false
```

If using the master computer to display a panel only, you may wish to create a full-screen panel for the aircraft you wish to fly (one is already available for the Cessna 172), and use the following options.

```
--prop:/sim/rendering/draw-otw=false (only render the panel)
--enable-panel
```

6.6 Recording and Playback

As well as the Instant Replay feature within the simulator, you can record your flight for later analysis or replay using the I/O system. Technical details of how to record specific FDM information can be found in the $FG_ROOT/protocol/README.protocol file.

To record a flight, use the following command line options:

```
--generic=file,out,20,flight.out,playback
```

This will record the FDM state at 20Hz (20 times per second), using the playback protocol and write it to a file flight.out.

To play it back later, use the following command line options:

```
--generic=file,in,20,flight.out,playback
--fdm=external
```

The playback.xml protocol file does not include information such as plane type, time of day, so you should use the same set of command line options as you did when recording.

6.7 Text to Speech with Festival

FlightGear supports Text To Speech (TTS) for ATC and tutorial messages through the festival TTS engine (http://www.cstr.ed.ac.uk/projects/festival/). This is available on many Linux distros, and can also be installed easily on a Cygwin Windows system. At time of writing, support on other platforms is unknown.

6.7.1 Installing the Festival system

1. Install festival from http://www.cstr.ed.ac.uk/projects/festival/

2. Check if Festival works. Festival provides a direct console interface. Only the relevant lines are shown here. Note the parentheses!

   ```
   $ festival
   festival> (SayText "FlightGear")
   festival> (quit)
   ```

3. Check if MBROLA is installed, or download it from here:

   http://tcts.fpms.ac.be/synthesis/mbrola/

   See under "Downloads"m "MBROLA binary and voices" (link at the bottom; hard to find). Choose the binary for your platform. Unfortunately, there's no source code available. If you don't like that, then you can skip the whole MBROLA setup. But then you can't use the more realistic voices. See below for details of more voices. Run MBROLA and marvel at the help screen. That's just to check if it's in the path and executable.

   ```
   $ mbrola -h
   ```

6.7.2 Running FlightGear with Voice Support

First start the festival server:

```
$ festival --server
```

Now, start *FlightGear* with voice support enabled. This is set through the /sim/sound/voices/enabled property. You can do this through the command line as follows.

```
$ fgfs --aircraft=j3cub \
        --airport=KSQL \
        --prop:/sim/sound/voices/enabled=true
```

Of course, you can put this option into your personal configuration file. This doesn't mean that you then always have to use FlightGear together with Festival. You'll just get a few error messages in the terminal window, but that's it. You cannot enable the voice subsystem when FlightGear is running.

To test it is all working, contact the KSFO ATC using the ' key. You should hear "your" voice first (and see the text in yellow color on top of the screen), then you should hear ATC answer with a different voice (and see it in light-green color).

ou can edit the voice parameters in the preferences.xml file, and select different screen colors and voice assignments in $FG_ROOT/Nasal/voice.nas. The messages aren't written to the respective /sim/sound/voices/voice[*]/text properties directly, but rather to aliases /sim/sound/voices/atc,approach,ground,pilot,ai-plane.

6.7.3 Troubleshooting

On some Linux distros, festival access is restricted, and you will get message like the following.

```
client(1) Tue Feb 21 13:29:46 2006 : \
  rejected from localhost.localdomain
not in access list
```

Details on this can be found from:
http://www.cstr.ed.ac.uk/projects/festival/manual/festival_28.html#SEC130.
You can disable access restrictions from localhost and localhost.localdomain by adding the following to a .festivalrc file in $HOME:

```
(set! server_access_list '("localhost"))
(set! server_access_list '("localhost.localdomain"))
```

Or, you can just disable the access list altogether:

```
(set! server_access_list nil)
```

This will allow connections from anywhere, but should be OK if your machine is behind a firewall.

6.7.4 Installing more voices

I'm afraid this is a bit tedious. You can skip it if you are happy with the default voice. First find the Festival data directory. All Festival data goes to a common file tree, like in FlightGear. This can be /usr/local/share/festival/ on Unices. We'll call that directory $FESTIVAL for now.

1. Check which voices are available. You can test them by prepending "voice_":

```
$ festival
festival> (print (mapcar (lambda (pair) (car pair)) \
                                        voice-locations))
(kal_diphone rab_diphone don_diphone us1_mbrola \
                    us2_mbrola us3_mbrola en1_mbrola)
nil
festival> (voice_us3_mbrola)
festival> (SayText "I've got a nice voice.")
festival> (quit)
```

2. Festival voices and MBROLA wrappers can be downloaded here:

   http://festvox.org/packed/festival/1.95/

   The "don_diphone" voice isn't the best, but it's comparatively small and well suited for "ai-planes". If you install it, it should end up as directory $FESTIVAL/voices/english/don_diphone/. You also need to install "festlex_OALD.tar.gz" for it as $FESTIVAL/dicts/oald/ and run the Makefile in this directory. (You may have to add "–heap 10000000" to the festival command arguments in the Makefile.)

3. Quite good voices are "us2_mbrola", "us3_mbrola", and "en1_mbrola". For these you need to install MBROLA (see above) as well as these wrappers: festvox_us2.tar.gz, festvox_us3.tar.gz, and festvox_en1.tar.gz. They create directories $FESTIVAL/voices/english/us2_mbrola/ etc. The voice data, however, has to be downloaded separately from another site:

4. MBROLA voices can be downloaded from the MBROLA download page (see above). You want the voices labeled "us2" and "us3". Unpack them in the directories that the wrappers have created: $FESTIVAL/voices/english/us2_mbrola/ and likewise for "us3" and "en1".

6.8 Air-Air Refuelling

As the name suggests, Air-Air Refueling (AAR) involves refueling an aircraft (typically a short-range jet fighter) from a tanker aircraft by flying in close formation. There are two types of refueling system supported. The KC135-E tanker has a boom that connects to a receiver on the refueling aircraft. The smaller KA6-D deploys a hose, into which the refueling aircraft inserts a probe.

A number of aircraft support AAR, including the T-38, Lightning, A-4F, Vulcan, Victor (which can also act as a tanker) and A-6E. You can tell if a particular aircraft support AAR by looking at the AI/ATC menu. If the "Tanker" menu item is enabled, the aircraft support AAR.

6.8.1 Setup

To set up AAR, simply start FlightGear with an AAR-enabled aircraft, take-off and climb to 15,000ft. Once cruising at this altitude, select AI/ATC->Tanker, and select "Request", which will spawn a new tanker in clear air at approximately your altitude.

FlightGear will report the altitude, speed, and TACAN identifier of the tanker. Program your TACAN with the TACAN identifier reported by the tanker (from the Equipment->Radio Settings dialog, or your cockpit controls). Depending on your aircraft, the tanker may also appear on your radar. If you require more help to find the tanker, you can select "Get Position" to be told the tanker location relative to yourself

Turn to an appropriate heading, guided by the TACAN bearing (you should try a "leading" approach to close in on the tanker) and look for the tanker on the radar or nav. screen. Around 5nm away, you should reduce your speed to around 20kts faster than the tanker - a "slow overtake". The KC135 will be visible from about 10nm, the KA6-D, being smaller, just over 1 nm. If you find yourself overshootng, deploy your airbrakes.

Close to within 50ft of the tanker (don't get too close, or you may collide with the tanker itself). You should see indication in the cockpit that you are receiving fuel - there is a green light in the A4 fuel gauge, and you should see the indicated tank load increase.

Once your tanks are full, or you have taken as much fuel as you wish, close the throttle a little, back away from the tanker and continue your intended flight.

Successfully refueling is not easy and can take a lot of practise, as in real life. Here are some helpful hints for making contact.

1. Approach the tanker slowly. It is very easy to overshoot and be unable to spot where the tanker has gone.

2. If you are having difficulty matching the speed of the tanker due to the throttle being too sensitive, try deploying your airbrakes. This will require more power to achieve the same speed and will reduce the throttle sensitivity.

3. To reduce your workload, you may be able to use the autpilot to stay at the correct altitude and/or speed. This is technically cheating, though NASA recently demonstrated that an advanced autopilot can perform AAR without pilot intervention.

4. Bear in mind that as you receive fuel your aircraft will become heavier and the center of gravity will move, affecting the trim of the aircraft.

5. The tanker aircraft fly a clock-wise "race-track" pattern in the sky. While it is possible to stay connected during these turns, you may find it easier to wait until the tanker has settled on its new course before refueling. The tanker aircraft provide warnings when they are intending to turn.

6.8.2   Multiplayer Refueling

Refuelling is possible within a Multiplayer session using the KC135 or Victor. The pilot of this aircraft should use the callsign "MOBIL1", "MOBIL2" or "MOBIL3". Other numbers are acceptable, but only these three have A-A TACAN channels assigned. These are 060X, 061X and 062X respectively.

If the receiving aircraft uses a YASim FDM, there are no further complications. Should the receiving aircraft be JSBSim based, the user must make sure that there are no AI tankers in their configuration. This means disabling (commenting out) all refuelling "scenarios" in the relevant aircraft-set.xml and in preferences.xml.

MP refuelling works in exactly the same way as AI refuelling and is a fun challenge. It is best to ensure that your network connection is as free from interruptions as possible; the MP code does a degree of prediction if there is a "blip" in the stream of packets and this can make close formation flight very difficult or even impossible.

Part III

Tutorials

Chapter 7

Tutorials

If you are new to flying, an advanced simulator such as *FlightGear* can seem daunting: You are presented with a cockpit of an aircraft with little information on how to fly it.

In real life, when learning to fly you would have an instructor sitting next to you to teach you how to fly and keep you safe.

While we cannot provide a personal instructor for every virtual pilot, there are a number of tutorials available that you can follow to become a proficient virtual pilot.

7.1 In-flight Tutorials

FlightGear contains an in-flight tutorial system, where a simulated instructor provides a virtual 'lesson'. These vary between aircraft from simple tutorials teaching you how to start the engines on the aircraft, to full lessons teaching you how to fly for the first time. To access tutorials, Select Start Tutorial from the Help menu.

The tutorial system works particularly well with the Festival TTS system (described above).

For simplicity, run tutorials with AI aircraft turned off from the Options item on the AI/ATC menu. Otherwise, ATC messages may make it difficult to hear your instructor.

Each tutorial consists of a number of discrete steps which you must complete. Your instructor will provide directions on how to complete each step, and observer how you perform them, providing additional guidance if required.

Within a tutorial, to ask your instructor to repeat any instructions, press '+'. You can pause the tutorial at any time using the 'p' key. To stop the tutorial select Stop Tutorial from the Help menu.

7.1.1 Cessna 172P tutorials

If this is your first time flying, a number of tutorials exist for the Cessna 172P designed to teach you the basics of flight, in a similar way to a real flight school. The tutorials are based around Half-Moon Bay (KHAF) and Livermore Municipal (KLVK) airports near San Francisco. Both these airports are provided in the base package. To start the tutorials, select the Cessna 172P aircraft, and a starting airport of KHAF or KLVK, using the wizard, or the command line:

```
$ fgfs --aircraft=c172p --airport=KHAF
```

When the simulator has loaded, select Start Tutorial from the Help menu. You will then be presented with a list of the tutorials available. Select a tutorial and press Next. A description of the tutorial is displayed. Press Start to start the tutorial.

7.2 FlightGear Tutorials

The following chapters provide *FlightGear* specific tutorials to take the budding aviator from their first time in an aircraft to flying in the clouds, relying on their instruments for navigation. If you have never flown a small aircraft before, following the tutorials provides an excellent introduction to flight.

Outside of this manual, there is an excellent tutorial written by David Megginson – being one of the main developers of *FlightGear* – on flying a basic airport circuit specifically using *FlightGear*. This document includes a lot of screen shots, numerical material etc., and is available from

http://www.flightgear.org/Docs/Tutorials/circuit.

7.3 Other Tutorials

There are many non-*FlightGear* specific tutorials, many of which are applicable. First, a quite comprehensive manual of this type is the Aeronautical Information Manual, published by the FAA, and available at

http://www.faa.gov/ATPubs/AIM/.

This is the Official Guide to Basic Flight Information and ATC Procedures by the FAA. It contains a lot of information on flight rules, flight safety, navigation, and more. If you find this a bit too hard work, you may prefer the FAA Training Book,

http://avstop.com/AC/FlightTraingHandbook/,

which covers all aspects of flight, beginning with the theory of flight and the working of airplanes, via procedures like takeoff and landing up to emergency

situations. This is an ideal reading for those who want to learn some basics on flight but don't (yet) want to spend bucks on getting a costly paper pilot's handbook.

While the handbook mentioned above is an excellent introduction on VFR (Visual Flight Rules), it does not include flying according to IFR (Instrument Flight Rules). However, an excellent introduction into navigation and flight according to Instrument Flight Rules written by Charles Wood can be found at

http://www.navfltsm.addr.com/.

Another comprehensive but yet readable text is John Denker's "See how it flies", available at

http://www.av8n.com/how/.

This is a real online text book, beginning with Bernoulli's principle, drag and power, and the like, with the later chapters covering even advanced aspects of VFR as well as IFR flying.

Chapter 8

A Basic Flight Simulator Tutorial

8.1 Foreword

Aviation is about extremes:

- An airplane is quite fragile and flies at high speeds. Yet it is one of the safest forms of transport.

- Pilots must constantly follow rules and procedures. Yet an airplane is a symbol of freedom.

- With a little training, flight a small aircraft is easy. Yet if a problem occurs, you must be able to resolve it in a few seconds.

- Many flight tutorials are written with a lot of humor. Yet not taking flying seriously will bring you down to earth prematurely.

The aircraft used in this tutorial is the Cessna 172p. This is the aircraft used in many real life flight schools and a great airplane to fly.

The following articles complement this tutorial and will answer most questions that may arise as you read through. The first one in particular is a good introduction to the airplane's main components and controls:

- https://www.gleim.com/aviation/learn-to-fly/

- http://www.pilotfriend.com/training/flight_training/aero/principa.htm

- http://en.wikipedia.org/wiki/Aircraft

- http://en.wikipedia.org/wiki/Flight_controls

- http://en.wikipedia.org/wiki/Airplane_flight_mechanics

- http://en.wikipedia.org/wiki/Aircraft_engine_controls

- http://www.firstflight.com/flt1.html

- http://flightsims.ig-wilson.com/index.php?f16land

- http://www.navfltsm.addr.com/

This tutorial is accurate to the best of my knowledge, but will inevitably contain some mistakes. I apologize in advance for these.

8.2   Starting Up

There are a number of different ways to start *FlightGear* based on your platform and the distribution you are using.

8.2.1   MS Windows

On MS Windows, *FlightGear* has a GUI Wizard in which you can choose your aircraft and starting postion. First choose the Cessna 172p airplane as shown below. To match this tutorial do not choose the 2D panel version. (You may however find in the future that the 2D version is more appropriate for training). Click the **Next** button to choose your airport.

You can start from any airport for this tutorial, but I will assume that you will start from FlightGear's default airport of San Francisco (KSFO):

Once you have selected KSFO and clicked on the **Next** button, you can set any number of options for the simulator. For your first flight, I suggest starting at noon. I would also recommend that you start with a small resolution of 800×600. Later on, you can play around with the options and use a higher resolution, but this obviously adversly affects performance. Click on the **Run** button and *FlightGear* will start with the options you selected.
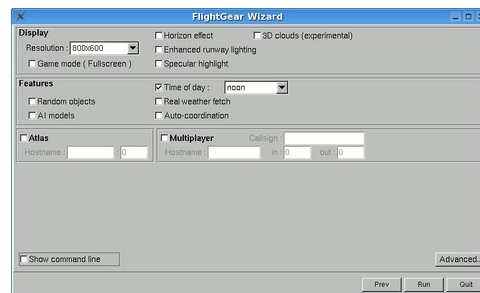
If you have problems running the latest version *FlightGear* on your Windows system, you may want to try an earlier version with lower graphics requirements (for example 0.9.8). You can find previous releases on the FTP mirrors mentioned at the top of the *FlightGear* download page: .

If you are running under Windows Me and the flight simulator suddenly starts stuttering, with the frame rate dropping, try killing all tasks except Explorer and Systray before you launch *FlightGear*. If one of the tasks you kill is an antivirus or such protection software, this is an obvious security risk. Also, on one Windows Me machine, a *FlightGear* of 800×600 yielded good results, while a lower resolution of 640×480 triggered much lower FPS levels (Frames Per Second).)

8.2.2 Linux and other unices

On Linux and other Unix-like systems, you may have to run *FlightGear* from the command line. If you have installed *FlightGear* but cannot find it in your menu system, try the following:

- From a terminal window (also named "console" window) try running the fgrun command. If installed, this will run the same GUI Wizard as under Windows as described above.

- Alternatively, open a terminal window and type the following command: `fgfs --timeofday=noon --geometry=800x600`.

8.2.3   In the dark?

Without the `--timeofday=noon` option, *FlightGear* will start at the current time in San Francisco - often night-time if you are in Europe. To change the time of day in the simulator to daytime, select **Environment->Time Settings** from the menu and select **Noon**.
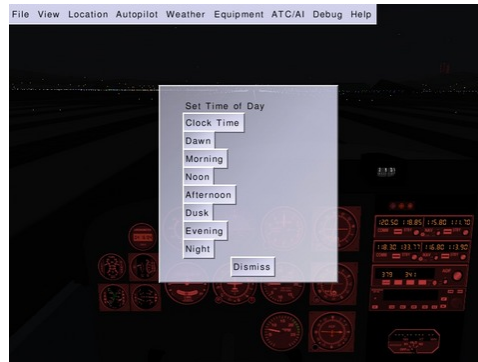
If running *FlightGear* from a menu (e.g. under KDE or Gnome), you can edit the FlightGear launch icon properties and change the simple `fgfs` fgfs command to something like `fgfs --timeofday=noon --geometry=1024x768`, or include whatever command options you wish. Further details of the command line options can be found in Chapter 4, *Takeoff: How to start the program.*

8.3   The First Challenge - Flying Straight

Once *FlightGear* is started you will see the following window and hear the sound of an engine:

On startup, the aircraft is at the end of the runway with the engine running at low power. The airplane will occasionally tremble a little, but it won't move.

About the keyboard.

- In this tutorial, a lowercase key letter indicates you should simply press that key. An uppercase means you must press shift and that key. (The ⇑ **Shift** keys are those two keys with a hollow fat arrow pointing upwards.) In other words: if you are told to type "v", simply hit the **v** key briefly. If you are told to type "V", press the **Shift** key down and while you have it pushed down, hit the **v** key, then release the **Shift** key. (In short: V is the same as **Shift−v**.)

- The tutorial will assume you have the **NumLock** switched on. When switched on, you should find a small green light on at the right of your keyboard. Press the **NumLock** key repeatedly until the lamp is on.

Press **v**, to view the aircraft from the outside. Type v repeatedly to scroll through a number of different views until you return to the cockpit. Typing **V** will cycle backwards through the views.):

In real life, we would have inspected the airplane all around to check everything is working, nothing is hampering the moving parts, and nothing is obstructing the instrument openings. In the simulator, this is already done for us before we start.

Hold the **Page Up** key down for about eight seconds. You will hear the engine sound rise.

The airplane will start accelerating down the runway. As it does so, it will drift to the left, before finally taking off, banking to the left, falling to the ground and crashing (probably).

You can see a replay of the crash using the **View -> Instant Replay** menu. Click the **Replay** button at the bottom of the dialog window, then use **v** and **V** to see the airplane from the outside. The picture below shows the end part of the flight. You can take a snapshot by typing the **F3** key. You can also use the **F10** key to toggle the menu bar on or off.

Having observed your crash, exit from *FlightGear*(using **File->Quit**) and restart the simulator using the same options as before.

In order to fly straight you need the airplane's control yoke:
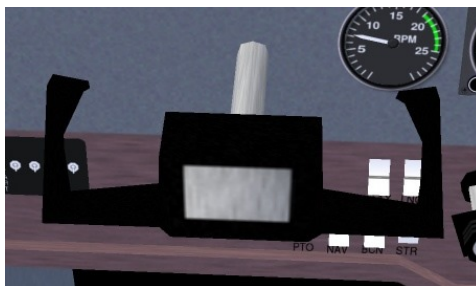
You can control the yoke using a joystick, or by moving the mouse. To use the mouse you need to be in mouse yoke mode. Get in that mode by pressing **Tab**. The mouse cursor becomes a + sign. Move the mouse and see the yoke moving accordingly. Type **v** to see the plane from the outside. If you move the mouse again you will see the tail elevator and the ailerons at both wings ends move. If your viewpoint is too far from the aircraft to see any movement, type **x** a few times to zoom in. Type **X** to zoom back out. **Ctrl-x** returns the view to the default zoom level. Type **V** to change the view back to the cockpit.

Pressing **Tab** again gets you in mouse view mode. In this mode the mouse cursor will be a ↔. sign. This allows you to look around easily by moving the mouse. Clicking the left mouse button will re-center the view. You can also change your view direction in the normal and yoke modes by holding down the right mouse button and moving the mouse. A further press of **Tab** will return you to the normal mouse mode.

To summarize, the **Tab** key cycles the mouse through three modes:

- *Normal mode*. This mode allows you to click on the menu and on the instrument panel.

- *Yoke mode*. The mouse controls the yoke (+ pointer shape).

- *View mode*. The mouse controls the view direction (↔ pointer shape).

Try taking off again using the mouse to control the yoke. Press **Tab** to put the mouse in yoke mode (+pointer shape) and raise the engine throttle to maximum by holding the **Page Up** key down. Do not try to keep the airplane rolling straight on the runway using the mouse/yoke. Let it drift leftwards. Wait till it rises in the air. Then use the mouse to try and get the airplane to fly straight. (If you want to control the airplane on the ground see section 8.5.)

You will find that you must prevent the airplane from banking to the left:

... or to the right:

... or from plunging to the ground:

Try to fly more or less straight, with the horizon stable slightly above the airplane nose:

Whatever your skills at video games or simpler simulators, you will probably not succeed at first. The airplane will crash, probably quite soon after take-off. This is the moment where most candidates get desperate and abandon trying to fly a simulator or a real aircraft. Just hold tight and keep trying. Eventually you will develop a feel for the subtle control inputs required.

The most common error is moving the mouse forwards to bring the nose up. In fact, you must pull the yoke by moving the mouse backwards to do this.

Equally, when you want to lower the airplane's nose, you must move the mouse forwards. This can seem odd, but all airplane control yokes are designed that way. With time, you will wonder how you every thought it worked any other way. You will also find that small mouse movements have a large effect on the aircraft. You may find that decreasing your mouse sensitivity may help initially.

If you have difficulty visualising this, the following analogy may help. Imagine a soccer ball is on your desk and you have "glued" your hand to the top of it. If you move your hand forwards the ball will roll forwards and your fingers will point to to the desk. If you move your hand backwards the ball will roll back and your fingers will now point up at the ceiling. Your hand is the airplane:

Another common error is the assumption that the control inputs directly match airplane bank. In other words, you believe if the control yoke is level, the airplane

will fly level. This is not true. The yoke controls the *rate* at which the airplane banks. If the airplane is banked 20° to the left and the control yoke is level, the airplane will stay banked at 20° left until some other force affects it. If you want to return the airplane to level flight, you have to turn the control yoke slightly to the right (move the mouse slightly rightwards) and keep it slightly to the right for a while. The airplane will turn slowly rightwards. Once it is level with the horizon, bring the control yoke level too. Then the airplane will stay level (until some other force changes its orientation).

A third error is trying to find "the right position" for the yoke/mouse. Naturally, you will want to find the fine tuning that will leave the airplane fly straight. Actually there is no such ideal yoke position. The airplane is inherintely unstable in the air. You must constantly correct the airplane's attitude and keep it flying straight with tiny movements of the mouse. This may seem to take all your concentration intially, but just like driving a car, keeping the aircraft straight and level will soon become second nature. For longer flights, you will eventually use the autopilot to keep the airplane level, but this is outside the scope of this tutorial.

To help fine-tune your senses to the control inputs required, keep your eyes on the outside scenery and not get fixated on the instruments or the yoke. Check the angle of the horizon and its height above the airplane's nose. The horizon line and the airplane engine cover are your main flight instruments. Look at the instrument panel only once in a while.

While the mouse is in yoke control mode (+ pointer shape), don't move it close to the FlightGear window edges. Once the mouse leaves the window, it stops controlling the aircraft, often at the worse possible moment! If you wish to use the mouse outside of the window, first go back to standard mouse mode by pressing **Tab** twice.

You can also control the yoke using the four **keyboard arrow** keys or the keypad **8**, **2**, **4** and **6** keys. While initially this may seem easier than the mouse, you cannot make the very fine adjustments required for accurate flying, so it is much better to persevere with the mouse.

You may hear beeping sounds while flying around the airport. These are landing aid signals. Don't worry about them for the moment.

You will know that you have mastered this when you can make the aircraft climb steadily in the air. The next step is to learn to keep the aircraft at a constant altitude, or to make it ascend or descend slowly and under your control.

Keeping the aircraft at a constant altitude involves observing the altimeter and making small changes with the mouse forwards or backwards to stop the aircraft ascending or descending respectively.

The altimeter instrument is at the middle top of the instrument panel. The long needle shows hundreds of feet, the short needle shows thousands of feet. The altimeter below shows an altitude of 300 feet, approximately 100 meters.

As you ascend or descend the altimeter will change accordingly, turning anti-clockwise as you descend, and clockwise as you gain height. If you see the altimeter "unwinding" you will be able to tell that you are losing height and move the mouse backwards slightly to raise the nose. After a while you will notice that when flying level the nose of the aircraft is always in the same position relative to the horizon. This is the aircraft attitude for level flight. By putting the nose in that same position, you will achieve almost level flight without having to reference the instruments. From there you can fine-tune your altitude.

Beware: an altimeter does not automatically show the absolute altitude above sea level. You must adjust for the local air pressive. The little black knob on the lower left side of the altimeter allows you to adjust the altimeter. Start *FlightGear* and stay on the ground. Click (in normal mouse mode) inside the black knob. A click on the left half makes the altimeter turn back. On the right half the altimeter turns forward. Use that little knob to tune in the current altitude. The principle is you use the knob when you are sure about the altitude. If you know you are at 1,100 feet altitude, tune in 1,100 feet on the altimeter. Clicking with the middle mouse button makes the knob turn faster, or you can use the scrollwheel on your mouse. Type **Ctrl-c** to see the two button halves highlighted.

To make settings the altimeter easier, airports advertise their altitude in various ways. They may provide a radio service (called ATIS in the USA) to broadcast the current air pressure at sea level. This is expressed in inches of mercury. The altimeter contains a small scale inside which is calibrated in this way. You can set your altimeter using this scale. Alternatively, if you are on the ground and know the altitude of the airport, you can simply adjust your altimeter until it displays the correct altitude.

Note that there is an important difference between "altitude above sea level" and "altitude above the ground". If you fly near Mount Everest at an altitude of 24,000 feet above sea level (AMSL), your altitude above the ground (AGL) will be much less. Knowing the altitude of the ground around you is obviously useful.

8.4 Basic Turns

While if you had enough fuel you could return to the same airport by flying straight head for thousands of miles, being able to change direction will make your flying more enjoyable and useful.

Once you are able to fly more or less straight, it is time to learn to turn. The principle is simple:

- When the airplane is banked to the left, it turns to the left.

- When the airplane is banked to the right, it turns to the right.

To turn, you do not need high levels of bank. 20° is more than enough for a safe and steady turn. The turn coordinator indicates your angle of bank by showing a depiction of your aircraft from behind. The picture below shows the turn coordinator when the airplane is banked 20° to the right. You can also tell the bank angle by observing the angle of the horizon.

Try the following: keep the airplane banked around those 20° for a few minutes and keep your eyes outside the aircraft You will see the same ground features appear again and again, every 120 seconds. This shows you need 120 seconds to make a 360° turn (or 60 seconds for a 180°)turn). This is particularly useful when navigating. Whatever speed the airplane is flying, if you bank at 20° you always need 60 seconds to make a 180° turn in the Cessna 172P.

So, by banking the airplane to the left or to the right, you make it turn to the left or to the right. Keeping the airplane level with the horizon keeps it flying straight.

The little purple ball in the bottom of the turn indicator shows the sideways forces. In real life you would feel these as your turn, however it is not possible to simulate these, so you must simply keep an eye on the ball. If you turn neatly (using the rudder a little bit), the ball will remain centered. If the ball is pushed say rightwards, this means you the pilot too are pushed rightwards. Like in a car turning to the left. During a neat turn in an airplane, even a strong turn, the passengers never endure a sideways force. They are only pushed a little harder on their seats by the centrifugal force.

By experimenting you will notice you can make much steeper turns by banking the airplane to high angles and pulling back on the yoke. Turns at over 60° bank angle are the realm of aerobatics and military flying, and dangerous is aircraft such as the Cessna.

8.5   Taxiing on the ground

While *FlightGear* starts you by default conveniently lined up on the runway and ready to go, you may be wondering how to get your aircraft from its hangar, along the taxi-ways to the runway. This is taxiing.

The picture below shows the instrument. It displays how fast the engine is turning in hundreds of revolutions per minute (RPM).

Type the **Page Up** key a few times, until the tachometer is showing 1,000 RPM (as shown above). If required type the **Page Down** key to decrease the engine speed.

At roughly 1,000 RPM, the airplane will move forward on the runway, but it will not accelerate and take off.

Type the "**.**"key (**Shift-;** on Azerty keyboards). The airplane will make a sharp turn to the right. If you keep the "**.**"key down the airplane will halt. When you type the "**.**" key, you are activating the brake on the right wheel of the airplane.

To activate the brake on the left wheel, use the "**,**" key.

The "**,**" and "**.**" keys simulate two brake pedals located at your feet on a real airplane. Using the throttle and the brake pedals you can control the speed of the aircraft and cause it to turn on the ground.

The brakes can be very useful when taxiing slowly on the runway. You can also steer the nose-wheel of the aircraft. In a real airplane this is done by pushing the rudder pedals with your feet. You push with your feet on the side you want to turn towards. If you don't have real rudder pedals, there are two ways to control the virtual rudder pedals:

- Using the keypad **0** and **Enter** keys . If you type the keypad **Enter** key say seven times, you will see the airplane firmly turns to the right and stays turning that way. Type the keypad **0** key seven times to get the airplane back rolling (almost) straight.

- Using the mouse. While the mouse is in yoke control mode (+ pointer shape), if you hold the left mouse button down, the mouse controls the rudder pedals instead of the yoke. The rudder pedals are connected to both the rudder and nose-wheel. This method is much more precise.

Start the simulator, Type **v** or **V** to view the airplane from the outside and keep **x** down a couple of seconds to zoom in on the airplane. Look at the front wheel

and keep keypad **O** down. Then keep keypad **Enter** down. See the front wheel turn. Press **Tab** to get in yoke control mode (+ pointer shape). Keep the left mouse button down to get in rudder control mode and move the mouse to the left and to the right. Note that the rudder, that big vertical control surface at the rear of the plane, moves together with the front wheel.

I tend to control the rudder pedals using the mouse while the front wheel is on the ground and use the keypad **O** and **Enter** keys once it has lifted off. In other words: I keep the left mouse button down while the front wheel is on the ground. This allows for a precise and easy rudder control on the ground. Then I simply release the left mouse button once the front wheel lifts off.

8.5.1 Airspeed

Just like driving a car, it is good to know how fast you are traveling. The aviation equivalent of a speedometer is the airspeed indicator (ASI), calibrate in nautical miles per hour (knots).

A knot is 1.85325 kilometer/hour. So, if you want to have a rough idea of your speed in flight expressed in km/h, multiply the knots displayed by 2. A knot is 1.15115 miles per hour, so very roughly, 1 knot is 1 mph. Note that some aircraft ASIs (in particular the Piper J3 Cub) display mph instead of knots.

The airspeed indicator displays the speed of the aircraft compared to the surrounding air, not the speed compared to the ground like a car speedometer does. If the plane is halted on the ground and there is a 10 knot wind blowing from straight ahead, the airspeed indicator will display 10 knots airspeed, although the plane will not be moving relative to the ground.

When the airplane rolls over the runway at more than 40 knots, you must prevent the front wheel from touching the ground. The nosewheel is not designed for high speeds and in real life would shimmy and wear out.

During take off, once over 40 knots you can make the front wheel leave the ground by pulling back gently on the control yoke. Don't turn sharply at high speed on the ground. Doing so may cause the aircraft to tip over.

The picture below shows the front wheel slightly lifted. Don't overdo this. Keep the airplane's white nose cover well below the horizon. You just need to lift the plane's nose very slightly.

Question: if the front wheel no longer touches the runway, how do you steer the airplane? Answer: still using the rudder pedals. As mentioned above, the rudder pedals are linked to both the nose-wheel and the tail rudder, that big vertical moving part at the tail of the plane:
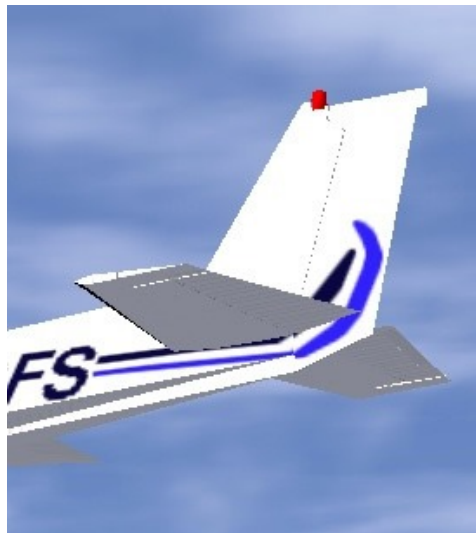
At airspeeds above 40 knots, the rudder has enought air-flow over it to steer the airplane.

Note the front wheel and the tail rudder don't make the airplane turn at exactly the same rate. So when the rudder takes over the front wheel, you must adapt the rudder pedals angle. That means fast typing keypad **0** and keypad **Enter** (or hold the left mouse button down and tightly control the rudder with the mouse).

Once you've become familiar with the nose-wheel and rudder, you can use these new controls to keep the airplane straight on the runway during take-off.

Say the airplane is heading too much to the right. You type keypad **0** a few times to make it turn back to the left. Don't wait till the aircraft has straightened up completely. Type keypad **Enter** before the aircraft reaches the direction you wish to travel. Otherwise you will find that you will over-correct and have to turn back again. If you use the mouse, such corrections are much easier and more precise.

To summarise: two methods exist to steer the airplane on the ground: the differential brakes on the side wheels and the rudder pedals. This control redundancy is very common in aviation. If one method fails, you still have another method available to perform the task.

You may be wondering why the aircraft drifts to the left when it rolls on the ground, forcing your to compensate with a little push on the right rudder pedal? The main reason is the flow of air produced by the propeller. It blows along the airplane body, but also corkscrews around the airplane fuselage. The upper part of that slight vortex pushes the vertical tail to the right. This causes makes the front of the aircraft to yaw to the left.

You can center all yoke and rudder controls by typing **5** on the keypad. This is a good preflight precaution. Sometimes it can "save your life" in flight if you find yourself with controls all over the place!

8.6 Advanced Turns

As with turning on the ground, there are two methods of turning in the air. You can use the wing ailerons (steered by the yoke/mouse) as described above or you can use the tail rudder (steered by the rudder pedals / the keypad keys **/0** and **Enter**.

Why two ways? Partially for redundancy, but mainly because they are complementary. The main effect of the rudder is yaw (rotation around the vertical axis), while the main effect of the ailerons is roll (rotation around the longitudonal axis).

- When flying close to the ground, it is better not to bank the airplane in order to turn. The rudder is used more instead. Acting on the rudder pedals allows you to turn the airplane without excessive banking.

- When the plane is just above the runway, the two side wheels need to be at the same height above the runway for landing. That means the wings must be level with the horizon. The plane is not allowed to bank. You keep the plane wings level with the horizon by using the yoke/mouse/ailerons. Note this does not need to be perfect. A bank of a few degrees is harmless.

- In flight, especially at high speed, the rudder is an in-efficient way to turn the aircraft:

    - It causes the airplane to present its flank to the airstream, increasing drag.

  – The airplane turns very slowly.

  – You will lack control while turning.

  – At high flight speed the centrifugal force will be disturbing or even dangerous.

Using the yoke/mouse/ailerons allows for efficient, fast, reliable and comfortable turns.

• The rudder can be vital when the wings are stalled. Indeed, during a stall the wing ailerons become less effective or even useless. (Note that some airplanes can go in a very dangerous stall if you overdo the rudder control at low speed.)

When you turn in flight, using the ailerons, you still need the rudder a little bit. You add a little bit of rudder. This allows you to compensate for the adverse yaw created when you roll using the ailerons. In a real aircraft, you can feel this sideways motion. In the simulator, you can check this visually on the turn coordinator. In the picture below the little ball is pushed rightwards during a strong turn to the right using the ailerons. That means you the pilot endure a rightwards force too. You can compensate this by pushing the right rudder pedal (type the keypad **Enter** key a few times). In normal flight you should use the rudder to keep the little ball centered.
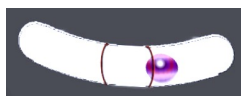
So, in normal flight use the ailerons to turn, while close to the ground at low speed use the rudder. However, one method never completely cancels out the other. You still need the rudder at high altitudes and speeds. Reciprocally you have to use the ailerons a little bit when close to the ground, to keep the wings level with the horizon.

Even when taxiing, you should use the ailerons. Otherwise, strong winds can blow the aircraft onto its side. To counteract this, your should turn the ailerons into the wind. This raises the aileron in the wind, helping to keep the wing down.

You should avoid making quick and agressive movements of the rudder. On the ground at high speed this can make the airplane turn too sharply. In flight at low speed it can cause a very dangerous type of stall. In flight at high speed it can cause all kinds of aerodynamic and physical discomfort. Instead, make gentle movements of the rudder.

I recommend you practise turning with the rudder in flight. Fly at a low speed of about 70 knots. Try to keep the altitude stable by increasing and decreasing the engine power. Use the rudder to turn towards a ground feature and maintain a heading, then turn the aircraft towards a new heading. See how the plane yaws. Learn to anticipate rudder control. Don't try to make steep turns. Use the yoke/ailerons to keep the wings level constantly.

8.7 A Bit of Wieheisterology

Wieheisterology comes from the German phrase "Wie heißt Er" – "What's that name". This section is about gauges, switches and controls of the aircraft. While in the simulator you can take off and land a basic airplane with just the engine throttle and the yoke, but you will need all the controls to perform securely and efficiently.

8.7.1 Engine control

An airplane engine is designed for simplicity, reliability and efficiency. Rather than use advanced electronic ignition and fuel injection systems found in modern cars, they instead use older technology that doesn't rely on electrical power. That way, the plane can still fly even if it suffers complete electrical failure.

Magneto

On the bottom left, below the instrument panel you will find the magneto switch and engine starter:
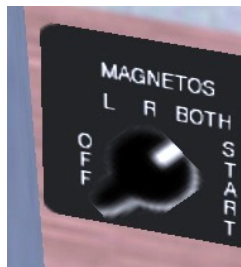
To see the switch, either type **P** to get the schematic instrument panel or type **Shift-x** to zoom out (**x** or **Ctrl-x** to zoom back in).

You can move the switch with the **{** and **}** keys (use the **Alt Gr** key on Azerty keyboards).

You are probably aware that the fuel inside a car engine is ignited by electric sparks. Modern car engines use electronic ignition. An airplane engine uses a more old-fashioned (but more reliable) magneto ignition instead. For redundancy, it contains two such magnetos: the "left" one and the "right" one. When you change the magneto switch on OFF, both magnetos are switched off and the engine will not run. With the magneto switch on L you are using the left magneto. On R you are using the right magneto. On BOTH you use both. In flight you will use BOTH.

Given that you use both magnetos in flight, why have the switch? The reason is that during your pre-flight checks you will verify that each of the magnetos is working correctly. To do this, increase the RPM to about 1500 then switch the magneto switch to L and observe the tachometer. You should observe a slight

drop in RPM. If the engine cuts out, the left magneto is broken. If you do not see an RPM drop, then the switch may be faulty, as both magnetos are still switched on. You can then perform the same test on the right magneto. Of course, in the simulator, the magnetos are unlikely to fail!

Should one of the two magnetos fail in flight, the other one will keep the engine running. The failure of one magneto is rare, the failure of both simultaneously is almost unheard of.

You may have typed **{** to shut the engine down. To start the engine again after doing so, type **}** three times in order to put the magneto switch on BOTH. Then use the starter motor by pressing the **s** for a few seconds, till the engine is started.

You can also turn the magneto switch and start the engine by clicking left and right of the switch in normal mouse mod). Type **Ctrl-c** to see the two click sides highlighted by yellow rectangles.

If you turn the switch to OFF, the engine noise stops. If you quickly turn the switch back to L, the engine starts again as the propeller is still turning. If you wait for the propeller to stop, placing the switch on L, R or BOTH won't start the engine. (Once the engine is halted, always place the magneto switch to OFF.)

Throttle
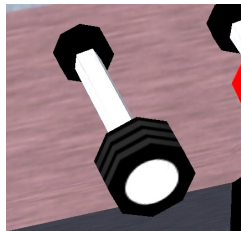
You already know that you increase the engine power by pushing that throttle rod in (**Page Up** key). You decrease the power by pulling the control out (**Page Down** key). You can also click left and right of the lever (middle mouse button for quicker moves, **Ctrl-c** to highlight the left and right halves).

What does "increase the power" actually mean? Does it mean you increase the amount of fuel delivered to the engine? Yes, but this is not enough to fully understand what you are doing. You need to be aware that the engine is also fed with a huge amount of air. The engine's cylinders burn an mixture of fuel and air. Fuel alone wouldn't burn. Only a mixture of fuel and air can detonate and move the engine pistons. So when you push the throttle in, you increase both the fuel and the air fed to the engine.

Mixture

The amount of air compared to the amount of fuel is critical. The proportion of the two has to be tuned closely. This is the purpose of the mixture lever. The picture below displays the mixture lever, pulled out far too much.
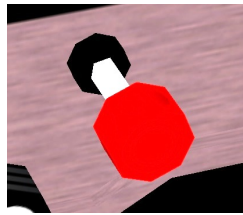
When the mixture lever is fully pushed in, you feed the engine with an lots of fuel and little air. This is known as a "rich" mixture. When the lever is pulled out completely, there is an excess of air, known as a "lean" mixture. The correct position to produce maximum power is in between these two extremes, usually quite close to fully pushed in.

When you start the engine and when you take off, you need a fuel-rich mixture. That means the mixture lever should be pushed in. A fuel-rich mixture allows the engine to start easily. It also makes the engine a little more reliable. The drawback is that a part of the fuel is not burned inside the engine. It is simply wasted and pushed out the exhaust. This makes the engine more polluting, it decreases the energy the engine can deliver and it slowly degrades the engine by causing deposits of residues inside the cylinders.

Once in normal flight, you have to pull the mixture lever a little, to get a more optimal mixture. Check this out by doing the following. Start the simulator. Put the parking brakes on with key B (that is **Shift-b**). Push the throttle in to its maximum. The engine RPM should now be close to the maximum. Slowly pull on the mixture lever (using the mouse in normal pointer mode). You will see the RPM increases a little. You get more power, without increasing the fuel intake. You waste no fuel and it pollutes less. If you continue to pull the mixture lever, the RPM will decrease back away, because now there is too much air. The excess of air slows the explosions down inside the cylinders and decreases the explosion temperature, hence the thermodynamic yield decreases. You have to tune in the optimal mixture. For thermodynamic reasons, the best mixture isn't exactly at maximum power - it is better for the engine to be running very slight richer or leaner than maximum power. This also avoids the possibility of the fuel detonating explosively damaging the engine. You can find the maximum power point by the fact you get the highest RPM. (Another method is to check the engine exhaust temperature. Roughly, this is the point at which you get the highest temperature.)

The mixture control allows you to burn less fuel for the same speed and distance, and therefore fly farther and pollute less. However, if you mis-manage it, it can cause serious problems. Suppose you go flying at high altitude and pull out the mixture lever accordingly. At high altitude there is less oxygen available so the correct mixture will be quite lean - i.e. with little fuel being used. Then you descend back in order to land. If you forget to push the mixture lever in as you descend, The fuel/air mixture will become far too lean and the engine will simply halt.

When landing, you have to tune back in a mixture that is a little too rich in fuel. This means pushing the mixture lever in. That way the engine becomes a little more reliable and will be better adapted to a decrease in altitude.

I wrote above that placing the magneto on OFF is not the right way to stop the engine. The right method is to pull the mixture lever. First pull the throttle out completely, to get the engine to minimum power and fuel consumption. Then pull the mixture lever, till the engine stops because the mixture contains too much air. This ensures the engine doesn't get choked by waste fuel residues. Finally, turn the magneto switch to OFF to ensure the engine won't start again accidentally.

An important warning: you may think the RPM indicator reflects the engine power. Wrong. Two things make the RPM increase: the engine power and the airplane speed. To check this, fly to a given altitude then pull the engine power to minimum. Try out diving to the ground then rising back to altitude. You will see the RPM varies significantly as does your airspeed. It rises while diving and decreases while climbing.

One pitfall of this is when you intend to tune the engine power in for landing. Suppose you're descending towards the airport, flying fast. You know the ideal RPM for landing is around 1,900 RPM. So you pull the throttle till you get 1,900 RPM. You think you tuned in the appropriate RPM. You think you shouldn't bother any more about it. But when you level off, the plane's speed starts to decrease, along with the RPM. A few minutes later, you get the low flight speed you wanted. You don't see the RPM is now far too slow. You will either lose altitude or stall. Or both. Be cautious with the throttle and with the RPM indicator. Either pull on the throttle more steadily or be mentally prepared to push it back in quickly.

8.7.2   Wings and speed

Say you are flying with full engine power. Dropping the nose a little makes you lose altitude and raising the nose a little makes you gain altitude. You may think this is quite straightforward. The plane travels in the direction it is heading; the direction the propeller is heading. This is not the best way to think about it. This model would be fine for a rocket, but not for an airplane. A rocket is lifted by its engine, while a plane is lifted by its wings. That's a huge difference.

Get a big rigid square of cardboard, hold it horizontally in your hand with your arm stretched out and make it do fast horizontal movements while rotating your torso. When the cardboard moves flat through the air, it experiences no lift force. If you twist your arm slightly to give the cardboard a slight upward angle, you will feel it tends to lift in the air. There is an upward force acting on the cardboard. That's the way a wing holds a plane in the air. The wings have a slight upward angle and lift the airplane. The more angle you give the cardboard, the more lift force. (Till you give it too steep an angle. Then you will rather feel a brake force. The cardboard is "stalling" (see below).)

upwards force

speed
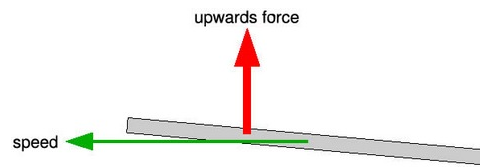
- When you pull the yoke, the airplane's nose rises up. Hence the wings travel through the air at a steeper angle. Hence the lift force on the wings is stronger. Hence the plane rises in the air.

- When you push the yoke, the airplane's nose dives. Hence the wings travel through the air with less angle. Hence the lift force on the wings decreases. Hence the plane descends.

What matters is the angle the wings travel through the air. This is the angle of attack.

I wrote above that when the wings travel through the air with no angle of attack, they don't produce lift. This is false. It would be true if the wings were a flat plate like the cardboard. But they aren't. The wings are a slightly curved airfoil. This makes them create lift even when traveling through the air at no angle of attack. Actually, even with a little negative angle of attack they still create a lift force. At high speed the airplane flies with the wings slightly angled towards the ground!

The angle at which the wings travel through the air matters. Something else matters too: the speed. Take the cardboard again in your hand. Hold it with a given slight angle and don't change that angle. Move it at different speeds through the air. The faster you move the cardboard, the more upward force it experiences.

- When you increase the engine power, the plane increases speed, the lift force on the wings increases and the plane gains altitude.

- When you decrease the engine power, the plane decreases speed, the lift force on the wings decreases and the plane loses altitude.

To make things a little more complicated: when rising in the air, the airplane tends to lose speed. When descending, it tends to gain speed.

That's all a matter of compromises. If you want to fly at a constant altitude and at a given speed, you will have to tune both the engine power and the yoke/elevator (or better: the trim (see below)), till you get what you want. If you want to descend yet keep the same speed, you have to push the yoke a little and decrease the engine power. And so on. You constantly have to tune both the engine power and the yoke. However, during a normal flight you can simplify this by simply choosing a comfortable engine power level then relying on the yoke and trim for altitude.

A very interesting exercise you can perform with the simulator is to fly straight with full engine power. Get maximum speed while keeping in horizontal flight. Then decrease the engine power to minimum. Pull steadily on the yoke to keep the plane at constant altitude. The plane slows down steadily, meanwhile you have pull more and more on the yoke to stay level. Since the speed decreases the lift from the wing will decrease, but you compensate the loss of speed by increasing the wing angle of attack. This proves the plane does not necessarily travel in the direction its nose is heading. In this experiment we make the nose rise in order to stay at constant altitude. Once the plane is flying very slowly, and the nose is very high, you may hear a siren yell. That's the stall warning (see below). This indicates that the angle of attack is too high for the airfoil to produce lift. The wings are no longer producing lift and the plane quickly loses altitude. The only way to correct this is push the yoke forwards to reduce the angle of attach, making the nose drop, then apply full power to gain speed and finally bring the yoke carefully back to level flight.

Question: is it better to control the airplane's speed and altitude with the yoke or with the throttle? Answer: it depends on what exactly you intent to do and on the situation you are in. In normal flight, as said above, you tend to set a comfortable engine power level, forget about it and rely on the yoke and trim. During take off and landing the procedures are quite strict about the use of yoke and throttle. You do the opposite: control the speed with the yoke and trim, control the altitude and descent speed with the engine throttle. This will be discussed further below.

8.7.3 The flaps

The flaps are situated at the rear of the wings, either side of the aircraft fuselage.
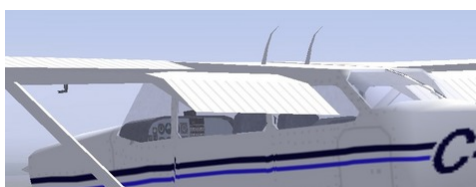
You deploy the flaps and retract them back in by using the flaps control lever:
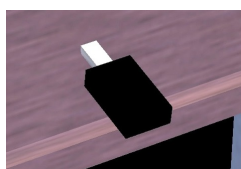
You can either click on it with the mouse or use the **[** and **]** keys. Key **[** to retract the flaps one step, **]** to deploy them one step at a time. Type **v** to view the plane from the outside and try out **[** and **]** . (On the schematic instrument panel the flaps lever is located at the lower right.)

In the Cessna 172P. there are four flaps settings:

- 0° - for normal flight and normal take off.

- 10° - for short field take off, when you want to gain altitude while flying slowly. Or during the first stange of an approach to land.

- 20° - to slow the aircraft and lose altitude quickly, for example when descending towards the runway to land.

- 30° - To lose altitude even more quickly.

The flaps are somewhat delicate. Do not deploy the first step of flaps above 110 knots. Do not deploy the second or third stage of flaps above 85 knots.

The flaps create large amounts of drag on the aircraft and brake the plane at high speed. This is one more reason not to forget to pull the flaps back in once you fly above 85 or 110 knots.

To check the flaps position visually, either use the mouse view mode to look at the back of the wing, or type **Shift-right arrow** to shift the view to the right and then quickly **Shift-up arrow** to get back to front view.

Flaps increase wing lift by altering the shape of the airfoil. The wing lifts more at a given speed with the first stage of flaps set. Hence you will get in the air a little sooner during take off. It also has the effect to make the plane fly with a lower nose attitude. This is useful as it provides a better view of the runway when taking off or landing.

The flaps also increase drag on the aircraft. The second and third stage of flaps produce much more drag than lift, so they are used to brake the plane. This is particularly useful when landing, because the airplane glides very well. If you cut down the engine power completely, the plane will descend, yet but too slowly. You need to deploy two or three flaps steps in order to brake and really descend towards the ground.

The fact that the flaps brake during landing makes you need more engine power during the landing. This can seem odd. Why not simply throttle the engine down to minimum and use less flaps steps? The answer is that it is better to have a strongly braking plane and lots of engine power, as the plane reacts faster to your commands. Should the engine fail, then just retract flaps as needed and glide to the runway.

What can you do if you have full flaps extended and need to increase your rate of descent further? Slowly push the rudder pedals on one side. This will make the plane present its flank to the air stream and brake. Compensate the turning by using the ailerons (yoke). This is known as side-slipping, and is a very effective way to lose height progressively as it is easy to stop at any point.

8.7.4 The stall

An aircraft relies on the smooth flow of air over the surface of the wing to produce lift. However, if the wing is at too high an angle of attack, this flow is broken, and

the wing no-longer produces lift. With no lift, the aircraft cannot fly, and quickly drops back to earth. This is known as a stall.

A stall is an emergency situation, whatever the While it can happen at any speed, it commonly occurs in slow flight. A given aircraft has a specific stall speed, at which no angle of attack can produce enough lift. You should always keep your aircraft well above the stall speed. To help, aircraft are equipped with stall sirens that sound when the angle of attack is approached.

If you encounter a stall, the remedial action is to immediately drop the nose, and apply full power, bringing the nose level when flying speed has been attained again. However, doing so will cause the aircraft to lose altitude, which you may not have to spare when landing or taking off!

A spin occurs when one wing stalls before the other, which can occur in a steep turn at low speed. As one wing is still flying, the aircraft turns around the stalled wing, spinning tighter and tighter. To get out of a spin, you need to apply rudder to straighten out the spin into a normal stall, then recover as above.

Aircraft like the Cessna 172 and Piper Cub, have benign stalls, and are unlikely to enter a spin. High performance jets, such as the F16 have much more agressive stalls, and can easily enter a spin.

To practise this in the simulator, do the following:

- Fly at constant altitude and attitude.

- Reduce engine power, raising the nose to avoid entering a descent.

- Continue to reduce power until the stall begins.

- Try to control the plane while it stalls and descends to the ground.

- Keep the yoke pulled to the maximum and the plane in a steady attitude, the wings parallel with the horizon. Try to change direction.

- Recover by lowering the nose, applying full power, and correcting the attitude once flying speed has been regained.

You can also experiment with stalls with different flap settings, and high speed stalls by making abrupt attitude changes.

Experiment with different aircraft. Compared with the Cessna 172 the Cessna Citation jet, stalls much more agressively and with little warning..

8.7.5   The trim

The trim is the dark big vertical wheel with gray dots located at the middle below the instrument panel:
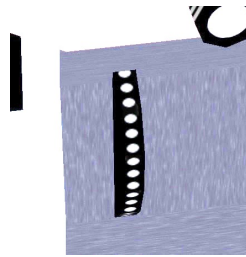
On *FlightGear*, the keys **Home** and **End** adjust the trim. **Home** rolls the wheel upwards while the **End** rolls the wheel downwards. You can also click on the upper or lower half of the trim wheel.

In first approximation, the trim does the same as the yoke: it acts on the elevator. Turning the trim wheel downwards is the same as pulling on the yoke. Yet there is a key difference between the trim and the yoke. The trim remains in position after you make a change, while the yoke only continues to affect the elevator while you apply pressure and returns the elevator to neutral when you release it.

During cruise flight, the required elevator position to keep the aircraft at constand altitude will not be completely neutral - it will vary depending on the air outside the aircraft, the current fuel level, and the payload. Obviously, holding the yoke continually to retain a constant attitude would quickly become tiring. By using the trim to "trim out" the elevator force required for cruise flight, the yoke can be kept neutral.

During take off the trim should be neutral. Otherwise you may find that it either refuses to take-off with the normal level of yoke control, or takes off too quickly.

During landing, try to get the yoke/mouse/elevator towards neutral position by tuning the trim. This makes making small adjustments to your attitude and position easier. On the Cessna 172p this means trim on neutral. On the Cherokee Warrior II this means the trim a little "pulled".

The trim wheel movement is much slower than the yoke, allowing for delicate changes in trim. Be patient.

8.7.6   What direction am I flying?

Knowing the direction you are going is obviously a good idea. There are three basic ways to determine the direction you are flying:

- Look through the windows. If you are flying regularly from the same airport, you will learn to recognize the ground features such as roads, hills, bridges, cities, forests. In a simulator, you only have a narrow view of the virtual outside world. Several ways exist to allow you to pan your virtual head inside the airplane:

    - Use **Shift** and the four arrow keys to look to the front, rear, left and right.

- – Use **Shift** and the keypad keys to look in the four directions mentioned above and in four diagonal directions in-between.

- – Hold down the right mouse button in normal or yoke mode and move the mouse to change the view direction.

- – Use the mouse in view mode (**Tab**, ↔). This allows you to look in every direction, including up and down. Click the left mouse button to bring the view back to straight ahead.

- The magnetic compass. This is located above the instrument panel. The compass is simple, but is affected by the acceleration of the aircraft, and magnetic abnormalities on the ground. Also, the compass points towards magnetic north rather than true north. This deviation varies depending on your location.
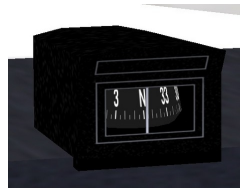
- The directional gyro (picture below) or "heading indicator". The gyro is powered by a vacuum system. The gyro is set to match the magnetic compass, and is not affected by magnetic issues, or aircraft movement. However, due to gyroscopic precession and friction in the instrument, over time it drifts and must be reset by reference to the magnetic compass on ocassion. To reset the HI, during cruise flight, use the black knob on the bottom left of the instrument (normal mouse pointer mode, click left or right half of the knob, middle mouse button to move faster, **Ctrl-c** to highlight halves). (The red knob, bottom right, is used to tell the autopilot what direction you wish to fly (**HDG** = "heading").

8.7.7   A look around the panel

Finally, let's have a look at the instrument panel, combining the instruments described above with some new ones.

The six-pack

Let us start with the most important instruments any simulator pilot must know, these are known as the "holy six" or the "six-pack" . In the center of the instrument panel (Fig. 5), in the upper row, you will find the artificial horizon (attitude indicator) displaying pitch and bank of your plane. It has pitch marks as well as bank marks at 10, 20, 30, 60, and 90 degrees.

Left of the artificial horizon, you'll see the airspeed indicator. Not only does it provide a speed indication in knots but also several arcs showing characteristic velocity rages you have to consider. At first, there is a green arc indicating the normal operating range of speed with the flaps fully retracted. The white arc indicates the range of speed with flaps in action. The yellow arc shows a range which should only be used in smooth air. The upper end of it has a red radial indicating the speed you must never exceeded, unless you want to break up the plane in mid-flights. . .

Below the airspeed indicator you can find the turn indicator. The airplane in the middle indicates the roll of your plane. If the left or right wing of the plane is aligned with one of the marks, this would indicate a standard turn, i.e. a turn of 360 degrees in exactly two minutes.

Below the plane, still in the turn indicator, is the inclinometer. It indicates whether the rudder and ailerons are co-ordinated. During turns, you always have to operate aileron and rudder in such a way that the ball in the tube remains centered; otherwise the plane is skidding. A simple rule says: "Step on the ball", i.e. step onto the left rudder pedal when the ball is on the left-hand side.

If you don't have pedals or lack the experience to handle the proper ratio between aileron/rudder automatically, you can start *FlightGear* with the option `--enable-auto-coordination`.

To the right-hand side of the artificial horizon you will find the altimeter showing the height above sea level (not ground!) in hundreds of feet. Below the altimeter is the vertical speed indicator indicating the rate of climbing or sinking of your plane in hundreds of feet per minute. While you may find it more convenient to use than the altimeter in certain cases, keep in mind that its display usually has a certain time-lag.

Further below the vertical speed indicator is the propellor tachometer, or RPM (rotations per minute) indicator, which displays the rotations per minute in hundreds. The green arc marks the optimum region for cruise flight.

The group of the main instruments further includes the gyro compass being situated below the artificial horizon. Besides this one, there is a magnetic compass sitting on top of the panel.

Four of these gauges being arranged in the from of a "T" are of special importance: The air speed indicator, the artificial horizon, the altimeter, and the compass should be scanned regularly during flight.

Supplementary Instruments

Beside the six-pack, there are several supplementary instruments. To the very left you will find the clock, obviously being an important tool for instance for determining turn rates. Below the clock there are several smaller gauges displaying the technical state of your engine. Certainly the most important of them is the fuel indicator - as any pilot should know.

The ignition switch is situated in the lower left corner of the panel (cf. Fig. 4). It has five positions: "OFF", "L", "R", "BOTH", and "START". The first one is obvious. "L" and "R" do not refer to two engines (as the Cessna 172 only has one) but the two magnetos, providing redundancy in the case of a failure.. The two switch positions can be used for test puposes during preflight. During normal flight the switch should point on "BOTH". The extreme right position is for using a battery-powered starter (operated with the "s" key).

The handle below the yoke is the parking brake. In the vertical position, the parking brake is ON. The parking brake is operated with the "B" key.

Radios

The right hand side of the panel is occupied by the radio stack. Here you find two VOR receivers (NAV), an NDB receiver (ADF) and two communication radios (COMM1/2) as well as the autopilot.

The communication radio is used for communication with air traffic facilities; it is just a usual radio transceiver working in a special frequency range. The frequency is displayed in the LEDs. Usually there are two COM transceivers; this way you can dial in the frequency of the next controller to contact while still being in contact with the previous one.

The COM radio can be used to listen to the current weather conditions at an airport, known as ATIS. To do this, simply dial in the ATIS frequency of the relevant airport. You can find this by selecting `ATC/AI->Frequencies` from the menu, and selecting the 4-letter ICAO code of a nearby airport.

Each COM radio has two frequencies configured - an 'active' frequency which the pilot is transmitting and receiving on, and a 'standby' frequency which may be changed. In this way, you can continue to listen on one frequency while tuning another one.

You can change the radio frequency using the mouse. For this purpose, click left/right to the circular knob below the corresponding number. The corresponding switch left to this knob can be used for toggling between the active/standby frequency.

Use of the autopilot and radio navigation equipement is covered in later tutorials. For the moment you can ignore these radio instruments as long as you are strictly flying according to VFR (visual flight rules).

8.8 Let's Fly

By now you will be able to keep on runway while taking off by using the rudder and you're able to fly straight, descend, climb and make gentle turns. This section will describe a slightly more realistic approach to taking off and landing, and introduce some of the more subtle concepts you should be aware of.

8.8.1 A realistic take off

The following general rules apply during a normal take-off:

- The nose-wheel should be lifted from the runway at approximately 40 knots.

- Immediately after take-off, you should accelerate to 70 knots, to stay well above stall speed, in case of a gust of wind, or engine failure.

- Don't fly much above 75 knots to ensure you gain height as quickly as possible.

- Follow the runway heading until at 500 feet. This way, if you suffer an engine failure, you can easily land back on the runway you left.

- Don't over-fly buildings until at least 1,000 ft.

- Close to the ground, turns should be gentle and well coordinated using the rudder.

So, you need to take off and rise in the air at a steady speed of around 75 knots. However, when you raise the nose slightly at 40 knots, the aircraft will probably take-off at around 55 knots. To accelerate quickly to 75 knots, lower the nose slightly immediately on take-off, then raise it once 75 knots has been achieved. You are using the yoke to control the speed of the aircraft.

Putting this all together with what you have learned previously, a normal take-off using the mouse will consist of the following:

1. Adjust the altimeter to the correct altitude, based on the airport altitude. For reference, KSFO is at sea level - 0ft.

2. Check aileron and elevator are neutral by observing the yoke position.

3. Change the mouse to control mode by pressing `Tab`.

4. Hold the left mouse button down to control the rudder.

5. Apply full power (hold `PgUp` until the throttle is fully in).

6. As the aircraft accelerates down the runway, keep it in the center by making small adjustments using the mouse.

7. As 40kts is reached, release the left mouse button, and pull back slightly to raise the nose-wheel. You are now controlling the yoke with the mouse.

8. The aircraft will fly off the runway at approximately 55 knots.

9. Lower the nose slightly to accelerate to 70 knots

10. Keep alignment with the runway.

11. Use the yoke to keep the ASI at 70 knots as you climb. If the airspeed is dropping, lower the nose. If the airspeed is increasing, raise the nose slightly.

12. Once you reach 500 feet, turn to your required heading, staying away from buildings until you are over 1,000ft.

8.8.2   Landing

The rules for landing are almost identical to that of take-off, but in reverse order:

- Close to the ground, turns should be gentle and well coordinated using the rudder.

- Stay above 500ft until on final approach to the runway

- Approach the runway at approximately 70 knots.

- Touch down on the two main wheels at 55kts.

- Let the nosewheel touch down at 40kts.

Landings are much easier if you have an aiming point picked out on the runway. By observing the aiming point, you can easily tell if you are descending too fast or too slowly. If the aiming point appears to move upwards, you are descending too fast,

Obviously, you need to be lined up with the runway. That means your flight direction has to match the middle line of the runway (drawing (a) below). In order to arrive at this, don't aim at the start of the runway (b). Rather aim at a fictitious point well in front of the runway (c). And begin to turn gently towards the runway well before you reach that fictitious point (d). Note the turns and bankings you make for these flight corrections are often very soft. You wouldn't even notice them on the turn coordinator. This is one example where you better rely on the outside horizon line than on the inside flight instruments.
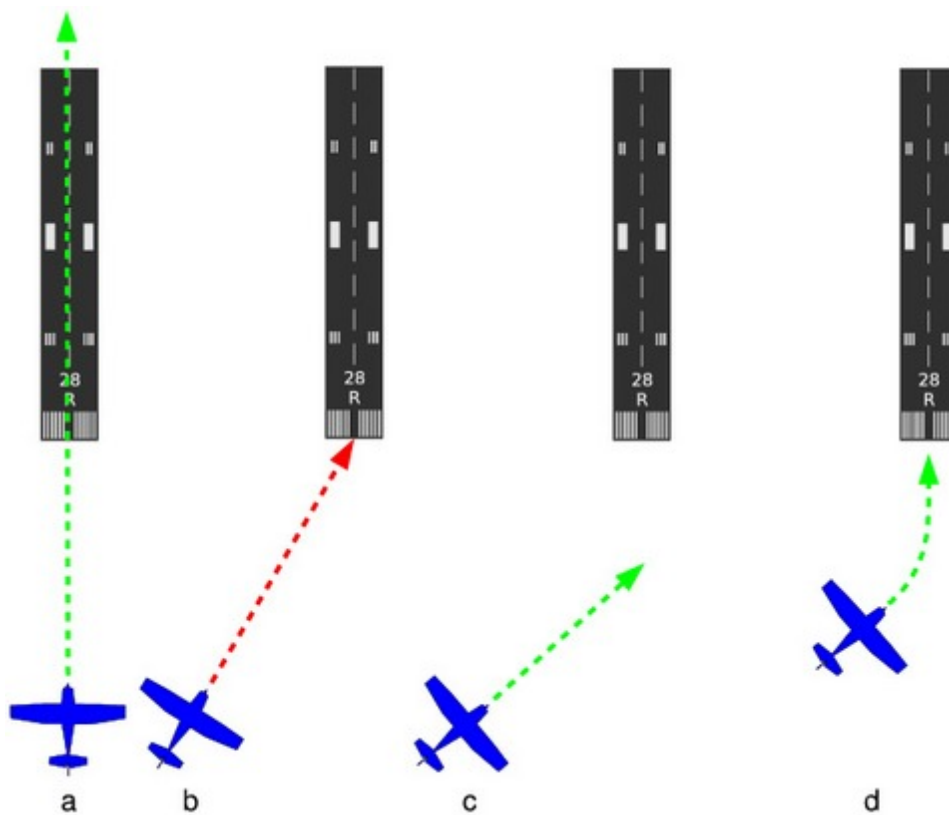
A straight in landing using the mouse would consist of the following:

1. 1,500ft above the airport, and a couple of miles out, an in-line with the runway, reduce power to approximately 1500rpm. This will slow you down somewhat and start a gradual descent.

2. Once below 115 knots, apply one step of flaps (`]`). This will increase lift, but also slow you down.

3. Re-trim the aircraft so you continue to descend.

4. At around 1,000 feet, apply another step of flaps (`]`). This increase drag significantly, but also improve the view over the nose.

5. Tune the speed using the elevator and trim: push the yoke if you are flying below 70 knots, pull the yoke if you are flying above 70 knots. If using a joystick, use the trim to relieve any pressure on the elevator.

6. Tune the altitude using the engine throttle. Add power if you are descending too fast, reduce power if you are too high. It is much easier to work out if you are too high or too low by observing the numbers on the runway. If they are moving up the screen, you are descending too fast - increase power. If they are moving down, you are too high and need to reduce power.

7. Make minor adjustments to heading to keep aligned with the runway.

8. at about 500ft, apply the final step of flaps. (`]`). This increase drag significantly, so be prepared to increase power to keep your descent constant.

9. When you are just above the runway, reduce power to idle, and use the yoke to gently pull back the aircraft to horizontal. This is the "round-out" and should result in the aircraft flying level with the runway a couple of feet above the surface. Performing the round-out at the correct height is a difficult task to master. To make it easier, observe the horizon rather than getting fixated on the aiming point.

10. Keep the wings level using small inputs with the yoke. We want both wheels to touch down at the same time.

11. Continue pulling back on the yoke. The main wheels should touch down at about 55 knots. This is the "flare".

12. As you touch down, be ready to use the rudder to keep the aircraft straight (keypad `0` and keypad `Enter`)

13. Once you are below 40 knots, lower the nose-wheel to the ground.

14. Hold down the left mouse button to control the nosewheel/rudder using the mouse.

15. Once below 30 knots, use the brakes `b` to slow the aircraft further.

Once the plane is halted or at very low speed, you can release the `b` key and add a little engine power to taxi to the parking or hangar.

8.8.3   Engine Shutdown

To shut the engine down:

- Set the parking brake, type `B`.

- Engine throttle to minimum (hold **Page Down** down for a while).

- Pull the mixture lever to halt the engine (mouse in normal pointer mode, click on the left of the red mixture lever to pull it out).

- Rotate the magneto switch to OFF (a few hits on **{**).

8.8.4 Aborted Landing

You must be mentally prepared to abort landing any time the landing doesn't look good, or due to external factors such as:

- an order from the control tower

- incorrect speed or landing angle when there is insufficient time to correct it.

- a strong gust blow of wind

- birds flying over the runway.

To abort the landing, apply full power (hold **PgUp**), raise the nose to climb, and once you are climbing, retract the flaps (key[).

Landing is much harder than taking off. Landing on a large runway, such as KSFO (San Francisco, the default) is much easier than smaller runways such as KHAF (Half Moon Bay, about 10 miles to the south west of KSFO).

To practise landings, use the command line below in a terminal window to start the simulator in flight and heading for the runway. The airplane is placed 5 miles ahead of the runway, at an altitude of **1500** feet and a speed of about 120 knots.

```
fgfs --offset-distance=5 --altitude=1500 --vc=120 --timeofday=noon
```

Approaching to land at 65 knots instead of 70 knots allows to use a much shorter runway length. However, this requires better control, particularly as it is much closer to the stall speed. It is quite different from landing at 70 knots.

8.9 Dealing with the Wind

Consider a hot air balloon. Think of it as being in the middle of a gigantic cube of air. The cube of air may move at high speed compared to the ground, but the balloon itself is completely static in the middle of the cube. Whatever the wind speed, persons aboard a hot air balloon experience not a breath of wind.

In the same way, an aircraft flies in the middle of a gigantic cube of air and flies relative to that air mass. The motion of the cube of air relative to the ground has no effect on the aircraft.

You, the pilot, on the contrary, are interested in the speed of the surrounding air compared to the ground. It can make you drift to the left or to the right. It can make you arrive at your destination much later or much sooner than planed.

When the wind blows in the same direction as you fly, the speed of the wind adds itself to the airspeed of the plane. Hence you move faster compared to the ground. You will arrive earlier at your destination.

When the wind blows in the opposite direction (towards the nose of the plane), the speed of the wind subtracts itself from the airspeed of the plane. Hence you move slower compared to the ground. You will arrive later at your destination and have more time to enjoy the landscape.

The two cases above are quite simple. More complex is when the wind blows towards the side of the airplane. Consider the diagram below.

- On picture (a) there is no wind. The pilot wants to reach the green hill situated to the North. He heads for the hill, towards the North, and reaches the hill after a while. When there is no wind, you just head towards your destination and everything's fine.

- On picture (b), the pilot keeps heading to the North. Yet there is wind blowing from the left; from the West. The airplane drifts to the right and misses the hill.

- On picture (c), the pilot keeps heading towards the hill. This time he will arrive at the hill. Yet the plane flies a curved path. This makes the pilot lose time to get to the hill. Such a curved path is awful when you need to make precise navigation.

- Picture (d) shows the optimal way to get to the hill. The plane is directed to the left of the hill, slightly towards the West and the wind. That way it compensates for the wind and remains on a straight path towards the hill.

a   b   c   d
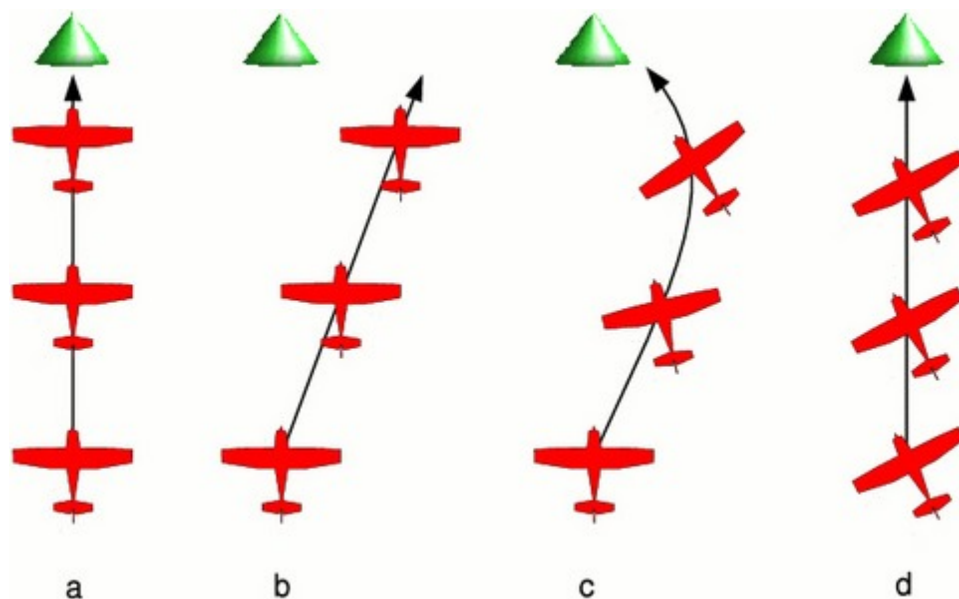
How much to the left or to the right of the object must you head? At what angle? Serious pilots use geometry and trigonometric computations to calculate the correct angle. You need no computations at all to fly roughly straight. The trick is to choose an aiming point in the direction you wish to fly, then observe how it moves. You will become aware if you are drifting leftwards or rightwards. Then let your instinct slowly head the plane to the right or to the left to compensate the obvious drift. To begin with, you may need to think about what you are doing. Very soon this will become automatic, just like when you learned to fly straight. You will no more keep the plane headed towards the object. You will rather keep it flying towards the object.

The faster the flight airspeed compared to the wind speed, the less correction you will need.

8.9.1 Crosswind Take Off

Taking off when the wind is coming from the side is tricky. Airport designers avoid this by placing runways so that they face into the prevailing wind. Often airports have multiple runways, placed such that there will be a runway facing straight into wind as much of the time as possible.

Taking off with a wind blowing straight towards the nose of the aircraft makes life easier as it is the speed of the wing relative to the air that causes lift. When there is no wind, the aircraft must accelerate to 55 knots to take off. However, if there is a 10 knot head-wind, the aircraft has an airspeed of 10 knots standing still and only has to accelerate to 45 knots relative to the ground to take off. This shortens take-off distances.

Just as a headwind shortens take-off, a tail-wind increases take-off length. Anything more than a knot or two makes a huge difference to take-off distance. As (most) runways can be flown from either end, you can easily take off from the other end of the runway and benefit from the headwing.

The main way to know the wind direction and speed is to go to the control tower or ask the control tower by radio. A necessary and complementary tool are the windsocks at both ends of the runway. They show the wind direction and speed. The longer and the stiffer the windsock, the more wind there is. The windsock on the picture below shows an airspeed of 5 knots:

Unfortunately, sometimes there isn't a runway facing the wind, and you have to take off when the wind is blowing from the side.

The technique is as for a normal take-off with two changes:

- During the take-off roll, the aircraft will try to "weather-cock" into wind. You must react by using the rudder to keep the aircraft running straight. You will have to apply the rudder at quite a strong angle to stay aligned with the runway. You will need to keep applying rudder throughout the take-off.

- As you take off, the aircraft will react to the rudder and try to turn. You will need to correct for this using the ailerons. Once the aircraft is in the air, you can reduce the rudder pressure and aileron, then correct for the wind, to keep aligned with the runway as described above.

8.9.2   Crosswind Landing

Landing in a crosswind is very similar to the take-off:

- Stay aligned with the runway by compensating for the crosswind.

- As you begin to round-out, use the yoke to straighten the aircraft so it is pointed down the runway. Apply rudder to stop the aircraft turning.

- The aircraft will land on one wheel first. Use the rudder to keep the aircraft pointed straight down the runway as the other wheel touches down.

The technique described here is the slip landing. Another crosswind landing technique is the crab landing.

8.9.3   Taxiing in the Wind

Under 10 knots wind the Cessna 172p seems not to need particular precautions when taxiing. Yet any sudden increase in wind speed can tilt it and tumble it over. So best apply the recommendations whenever there is wind.

To train taxiing on the ground when there is wind, configure the simulator for a strong wind, like 20 knots. Such a wind can tilt the plane and blow it away tumbling any moment. One single error during taxiing and the plane is lost.

Main rule is you must *push the yoke towards the wind*. This deserves some physical explanation:

- When the wind is blowing from 12 o'clock, this is quite logical. The yoke is pushed (towards 12 o'clock) and the elevator makes the tail rise a little. That's the most stable position to avoid the plane be tilted by the wind.

- When the wind comes from 10 o'clock, pushing the yoke towards 10 o'clock means that the elevator is almost neutral, while the left aileron is upward and the right aileron is downward. This pushes the left wing down and lifts the

right wing. Again, that's the most stable position to avoid the plane be tilted by the wind.

- When the wind blows from 8 o'clock, you would think you should invert the position of the ailerons, to keep the left wing being pushed down. Hence you should push the yoke to 4 o'clock. Wrong! Keep pushing the yoke to 8 o'clock. The reason is the downward position of the aileron on the right wing makes it act like a slat. This increases the lift on the right wing and this is all we want. Symmetrically, the upward position of the left aileron decreases the lift of the left wing.

- When the wind comes from the rear, from 6 o'clock, the yoke is pulled (towards 6 o'clock). The upward position of the elevator tends to make the tail be pushed down. Once again this is the best. Strong wind can push the tail against the ground. This is impressive but the tail is conceived to withstand this.

If you want to move towards the wind, you will need more engine power. When the wind blows from the rear you may need no engine power at all. Always keep the engine power to the minimum needed.

Especially when turning, move very slowly. Make little changes at a time. Take your time and closely survey the yoke angle. Constantly keep it pushed towards the wind. Constantly try to reduce the engine power. Keep in mind using the brakes too firmly may shortly tilt the plane at an angle that allows the wind to tilt it and blow it away.

8.10   The autopilot

An autopilot is not an "intelligent" pilot. It just takes over simple tasks for the pilot. You still are the pilot aboard and have to keep aware of everything. Be prepared to shut the autopilot down as they often go wrong, both in real life, and in the simulator.

The autopilot is mounted to the right of the yoke:

Switch it on by pressing the **AP** button. The autopilot then controls the roll of the aircraft. It keeps the wings level with the horizon. This is displayed in the picture below by the "ROL" marking. To switch the autopilot off press **AP** again.

If you press the **HDG** button the autopilot will try to keep the plane flying towards the direction tuned on the directional gyro by the red marking (see section 8.7.6). "HDG" stands for "heading". Press again on the **HDG** button to get back to roll control mode (or **AP** to switch the autopilot off).

The buttons **ALT**, **UP** and **DN** are used to tell the autopilot either to control the vertical speed VS or the altitude ALT. For more advanced use of the autopilot, see the reference document for the autopilot modelled in the Cessna 172: Bendix King website

8.11   What Next?

This tutorial has introduced you to the basics fo flight in the Cessna 172. From here you can explore the many features that *FlightGear* has to offer.

Once you have mastered the content of this tutorial, you may want to look at the other tutorials in this Manual, covering flying to other airports, flying using instruments when clouds obscure the ground, and flying helicopters.

This tutorial has skipped over a number of topics that a real-life pilot would have to consider:

- How to follow real checklists.

- How to make emergency landing on very short fields, after and engine failure.

- How to navigate with regard to the laws of the air, charts, laws, radio beacons and weather conditions

- How to create a flight plan and fly it accurately.

- How to place people, fuel and baggage in an airplane to get a correct center of gravity.

- How to deal with the control tower and with other airplanes.

- How to deal with several fuel tanks and their systems.

- How to deal with the failure of every possible part of the plane.

This tutorial has also not covered features of more advanced aircraft, including:

- retractable landing gear

- variable pitch propellers

- multiple engines

- jet engines.

8.12 Thanks

I wish to thank:

- Benno Schulenberg who corrected lots of mistakes in my English in this tutorial.

- Albert Frank who gave me key data on piloting and corrected technical errors.

- Vassilii Khachaturov who learned me new things about *FlightGear*.

- Roy Vegard Ovesen for pointing me to the official Autopilot Pilots Guide.

- Dene Maxwell for his solution for problems under Windows Me.

- Mark Akermann and Paul Surgeon for their remarks.

- Michael "Sam van der Mac" Maciejewski who made the translation in Polish and converted the tutorial for use in the manual.

- The *FlightGear* mailing list users for their hearty welcome.

- 4p8 webmaster my friend Frï¿$\frac{1}{2}$dï¿$\frac{1}{2}$ric Cloth for the web space used by this tutorial.

8.13 Flying Other Aircraft

I cross-checked all the data about the Cessna 172p, a pilot friend verified I did not write too much rubbish and I made numerous virtual test flights. This section contains less reliable data about other airplanes based on my experience in the simulator. You may find it useful as an introduction to those airplanes but bear in mind my only goal was to make flights that seem OK and acquire basic knowledge.

8.13.1   How to land the Cherokee Warrior II

The Cherokee Warrior II has some advantages upon the Cessna 172p. Thanks to its low wings it is far less sensitive to crosswind. Fully extended flaps are provide more braking and allow it to land on a much shorter distance.

Take off is the same as for the Cessna 172p in *FlightGear*. In real life their take off checklists are not exactly the same.

You have to get used to some minor differences of the Cherokee Warrior II for the landing:

- During the steady horizontal flight before landing, the trim must be pulled a little below neutral in order to get the yoke around neutral.

- The optimal tachometer RPM during landing is at a lower RPM than the tachometer green zone. Roughly, keep the needle vertical.

- Only put use two steps of flaps during landing.Don't decrease the engine throttle too much.

- If you remain at two flaps deployed during landing, the round-out and flar will be similar to the Cessna 172p. However, using the third set of flaps will slow the aircraft down dramatically. It will very quickly touch the runway then come to a near halt. Be prepared to lower the front wheel very soon. (It is possible to use the third flaps step during the descent towards the runway, instead of tuning the engine power down. Oscillating between two steps and three steps allows to aim the runway start. Yet keep two flaps steps and tune the engine seems easier. An interesting stunt is to fly stable till nearly above the runway start, then tune the engine to minimum and deploy three flaps steps. The plane almost falls to the runway. It's impressive but it works.)

In real life, an advantage of the Cessna 172p upon the Cherokee Warrior II is the fuel reservoirs of the Cessna are located in the wings close above the center of the plane and higher than the engine. What's more an automatic system switches between the reservoirs. That means you almost don't have to bother for the way the fuel gets to the engine in flight. On the contrary, on the Cherokee Warrior II the reservoirs are located separately, on both wings and lower than the engine. That means you have to constantly switch between the two reservoirs in flight. Should one reservoir become much lighter than the other, this would destabilize the airplane. The fact the reservoirs are lower than the engine means you have to control the fuel pumps and the backup fuel pumps.

Some links:

- http://en.wikipedia.org/wiki/Piper_Cherokee

- http://freechecklists.net/Resources/Piper/PA-28-151+Warrior/

8.13.2   How to take off and land the Piper J3 Cub

The Piper J3 Cub is a very different airplane from the Cessna 172p and the Cherokee Warrior II. The Cessna 172p and the Cherokee Warrior II are nose-wheel airplanes, while the Piper J3 Cub is a tail wheel airplane. Take off and landing with tail wheel airplanes is more difficult. You have to tightly use the rudder pedals when rolling over the runway. The yoke often needs to be pulled backwards to the maximum. The Piper J3 Cub is a good introduction to tail-wheel aircraft and it is quite easy to take off and land provided you follow an appropriate procedure. Stall speed seems to be a little below 40 mph (the airspeed indicator is in mph) (about 27 knots). Take-off is below 50 mph.

My take off procedure for the Piper Cub is to fully pull the yoke backwards then throttle the engine to maximum. Once the front wheels clearly rises from the ground, gently push the yoke back to neutral, towards a normal flight close above the runway. Let the plane accelerate to 50 mph. Then pull the yoke to keep a little more than 50 mph while rising in the air.

The landing procedure is quite different to that of 172, as the aircraft is very light, and has no flaps.

1. Fly at say 500 feet constant altitude and "exactly" 52 mph speed towards the runway. Let the engine cover eat up the runway start. The engine cover will hide the runway completely. To see where the runway is, push the yoke/mouse very shortly then stabilize again in normal flight.

2. Once the runway start matches with the set of instruments (if you could see through the instrument panel), reduce the throttle to a near minimum and begin the dive towards the runway start. Keep 52 mph using the yoke. Add some throttle if you are going to miss the runway edge. (Keep in mind just a little wind is enough to change things a lot for the Piper J3 Cub).

3. Make the rounding and pull the throttle to minimum. Do not pull steadily on the yoke. Instead let the wheels roll on the runway immediately.

4. Once the wheels roll on the runway, *push* firmly on the yoke, to its maximum. This rises the tail in the air. You would think the propeller will hit the runway or the airplane will tilt over and be damaged. But everything's fine. The wings are at a strong negative angle and this brakes the plane. (Don't push the yoke this way on other airplanes, even if their shape seems close to that of the Piper J3 Cub. Most of them will tumble forwards.)

5. The yoke being pushed in to its maximum, push the left mouse button and keep it pushed to go in rudder control mode. Keep the plane more or less centered on the runway. This is quite uneasy. One tip is to stop aiming the rudder to say the left already when the plane just starts to turn to the left.

6. Once the speed is really low (and the rudder control stabilized), you will see the tail begins to sink to the ground. Release the left mouse button to go back

to yoke control. Pull the yoke backwards completely, to the other extreme. The tail now touches the ground and the nose is high up. Now you can use the wheel brakes (**b**). (If you use the brakes too early, the plane nose will hit the ground.)

The take off procedure mentioned above is symmetrical to the first landing procedure. There exists a second take off procedure, symmetrical to the second landing procedure. Yet I don't succeed it properly so I won't write about it.

8.13.3 How to take off and land a jet

Take off on a jet is easy but you must have fast reflexes. My favorite jet on Flight-Gear is the A-4 Skyhawk. You get it with the `-aircraft=a4-uiuc` parameter on Linux, provided it is installed.

This is the "calm" procedure to take off:

- Ask for a red and full HUD by typing **h** two times. The engine throttle indicator is the leftmost on the HUD.

- The airspeed indicator is the one labeled "KIAS" on the upper left side of the instrument panel. You can also use the airspeed indicator on the HUD, of course.

- Tune in $\frac{1}{2}$ engine power.

- Keep the yoke pulled in $\frac{1}{2}$ of its total way (picture below: the red arrow on the right side of the vertical line in the middle of the picture).
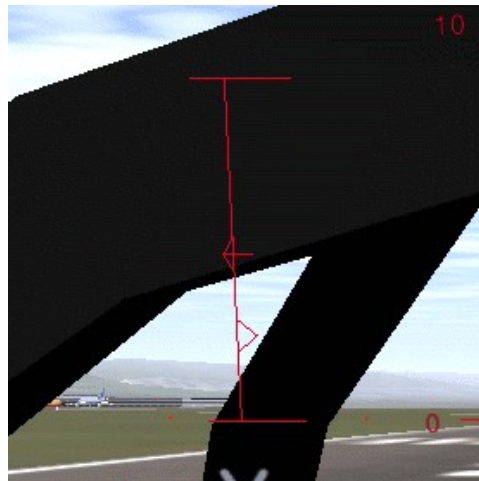
- It is not mandatory to use the rudder to keep on the runway. The airplane will take off before it drifts off the runway. (For sure it is better and more "secure" to keep in the middle of the runway. But using the rudder can make things hectic for a beginner.)

- Once above about 160 knots, the plane rises its nose in the air. Immediately push the yoke back to neutral or almost and stabilize at 200 knots airspeed (which makes a fair climb angle) (I've no idea whether 200 knots is the right climb speed for a real A-4. What's more I suppose one should rather use the AOA (see below).).

- Retract the landing gear using key **g**.

- Either maintain $\frac{1}{2}$ engine power and a speed of 200 knots to get above the clouds, or reduce the engine power to less than $\frac{1}{4}$ and fly normally. (Off course you can "fly normally" with full engine power. Great fun.)

The "nervous" take off procedure is the same but you push in full engine power. The plane takes off quickly and you need to settle a very steep climb angle to keep 200 knots. Best retract the landing gear immediately.

You don't land a jet the same way you land a little propeller airplane. My way to land the A-4, inspired by some texts I found on the Web, is this:

- Really far from the runway, keep below 2,000 feet and get the speed below 200 knots. Then lower the landing gear (key **G**) and I deploy full flaps (all three steps, by hitting **]** three times).

- Keep a steady altitude of about 1,000 feet and a speed of "exactly" 150 knots. Use the mouse/yoke/elevator to tune the altitude and the engine throttle to tune the speed. (The opposite from the Cessna.)

- Try to align with the runway.

- When do you know the dive towards the runway must begin? For this you need the HUD; the full default HUD with lots of features. Look at the picture below. When you see the "distance" between the red "0" lines and the runway start is 25% the distance between the red "0" lines and the red "−10" dotted line, it is time to dive, aiming at the runway start. (In the picture below, that "distance" is 64%, far too much to start a landing.)
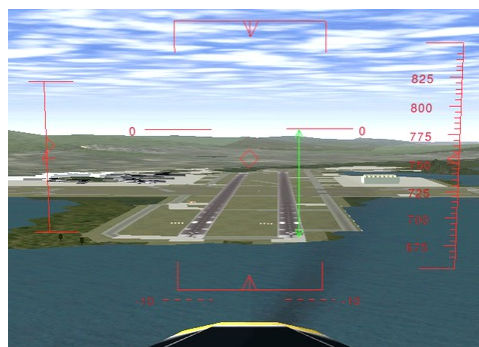
Let's explain this. The two horizontal lines labeled "0" show the horizon line. Rather they show where the horizon would be if the Earth was flat. When your eyes aim at those "0" lines, you are looking horizontally. Look at the dotted red lines labeled "-10". A feature on the ground situated there is situated $10°$ below the ideal horizon. In other words: when you look to objects "hidden" by the lines labeled "0", you have to lower your eyes of $10°$ to look at objects "hidden" by the dotted lines labeled "-10". This implies, and it is very important, that a person in a rowboat, "hidden" by the dotted lines labeled "-10", has to rise his eyes up $10°$ to look at your plane. He sees you $10°$ above the horizon. In the picture above, the start of the runway is situated at 64% of the way towards the red "-10" dotted lines. That means you have to lower your eyes of $6,4°$ to look at the runway start. This also means that if you start now to descent towards the runway start, the descent path will be of $6,4°$ (too steep). So, the HUD allows to measure precisely the angle of the descent path. On a jet plane you need an angle of $2,5°$ (up to $3°$), that is 25% of $-10°$ (up to 30%).
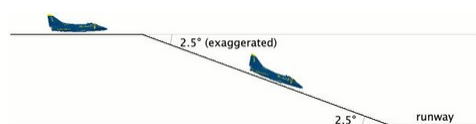
- Once descending towards the runway start, aim at it using the yoke/mouse. And keep 150 knots speed using the engine throttle lever.

- Keep measuring the angle between the ideal horizon and the runway start. It must keep $2,5°$ (that is 25% of $10°$):

  ○ If the angle increases above $2,5°$, you are above the desired path and you must loose altitude faster. Both decrease the engine power and dive the nose a little.

  ○ If the angle decreases below $2,5°$, you are under the desired path. I wouldn't say you should gain altitude, rather you should loose altitude less fast. Both add a little engine power and rise the nose a little.

- Once very close to the runway start, do no rounding. Don't pull steadily on the yoke like you would for the Cessna 172p. Simply let the plane touch the ground immediately, at high speed. Let it smash on the runway, so to say. All three wheels almost together. Just throttle the engine down to minimum. (If you try to pull steadily on the yoke and hover over the runway while the plane nose rises steadily, on a F-16 you would scrape the plane rear and probably destroy it.)

- Keep the key **b** down to brake and use the rudder to stay aligned with the runway. Make only very little tunings with the rudder, otherwise the plane will tumble on one of its sides.

The HUD in a real jet contains a symbol to show towards what the airplane is moving. It is shown in the picture below. When you are flying at constant altitude, that symbol is on the ideal horizon line. Once you dive towards the runway start, you simply have to place that symbol on the runway start. This is quite an easy and precise way to aim at the runway start. (The diamond in the center of the FlightGear HUD sometimes can help but it does not have the same purpose. It shows towards what the airplane nose is pointing. For example is you descent towards the ground at low speed, the symbol would be somewhere on the ground while the FlightGear diamond will be up in the sky.) (By the way, the HUD on the virtual B-52 on FlightGear has that symbol. It is great to use while landing.)

Also, a real HUD shows a dotted line at $-2,5°$, to help find the correct descent path. Simply keep that dotted line on the runway thresh-hold.

In additional to airspeed, military fast jet pilots rely on using the correct angle of attack during approach. The Angle Of Attack (AoA) is the angle at which the wings are pitched against the relative airflow. The advantage of keeping to an optimal AoA is that the optimal AoA for landing does not depend on the plane load, while the optimal airspeed speed does. By ensuring that the AoA is correct for every landing, you will land at the correct speed, whatever the plane load.

The Angle of Attack is displayed within the HUD, and/or as a set of three lights shown below. When the upper $\vee$ is lit, your angle of attack (AoA) is too high and you need to pitch down. When the lower $\wedge$ is lit, your AoA is too low and you need to pitch up. The center $\bigcirc$ indicates your the AoA is OK. Obviously, as you pitch up or down your airspeed and descent rate will change, so you will need to change your throttle setting appropriately.

The Cessna 172 and the A-4 Skyhawk are two extremes. Most other airplanes are in-between these two extremes. If you trained them both (and one or two tail wheel airplanes), you should be able to find out how to take off and land most other airplanes.

160 knots seems an appropriate landing speed for the F-16 Falcon. Also you need to throttle down the engine to minimum just before the plane should touch

the runway. Otherwise it will hover over the runway. Don't bother for the flaps. It seems they are deployed automatically with the landing gear. (Read the section 8.7.4 about the stall).

140 up to 150 knots and all 8 flaps steps deployed seem appropriate to land the virtual Boeing 737. But don't trust me especially on that one. I just made a few experiments and didn't search for serious data. The landing speed varies a lot depending on the plane load, I suppose 140 knots is for a plane with no load. The Boeing 737 seems to like a gentle rounding before the wheels touch the runway. Start the rounding early.

In the take off procedure for the Cessna 172 and the A-4 Skyhawk I recommend you pull the yoke/mouse/elevator to $\frac{1}{2}$ the total way, from the start on. This seems to be a bad practice on the Pilatus PC-7. Keep the elevator neutral. Let the plane accelerate and wait till the speed gets over 100 knots. Then pull calmly on the yoke. During landing, deploy full flaps once you start plunging to the runway but don't decrease the engine throttle. Decrease it only when the hovering above the runway starts. 100 knots seems a good landing speed.

For the Cessna 310 too you better leave the elevator neutral during the acceleration on the runway. The plane will raise its nose by its own provided you deployed one flaps step. (If you keep the yoke pulled from the start on, the nose will rise sooner and you will get yawful yaw problems.)

(Some virtual airplanes, like some big airliners or fast aircraft, need faster physical computations. Then add the `-model-hz=480` parameter to the command line. If the plane is difficult to control during landings, try this.)

The angle at which you land a Cessna 172p is far steeper than the narrow $2, 5°$ for a jet. Nevertheless you are allowed to land the Cessna at a narrow angle too. (Provided the terrain around the runway allows for this, of course.) If you have passengers who have ears problems with the variation of air pressure...

8.13.4   How to take off and land the P-51D Mustang

Should you ever get a chance to pilot a P-51 Mustang, just say no. It is quite dangerous to take off and land. That's the kind of airplane you fly only when your country is in danger. You need a lot of training. Yet once in the air the P-51 Mustang seems no more dangerous to its pilot than other common military airplanes. It is quite easy to pilot.

At low and medium altitude the P-51 wasn't better than the Spitfire and the Messerschmitts. The big difference was at high altitude. The P-51 kept efficient and maneuverable while enemy fighters were just capable to hang in the air. This was an advantage at medium altitude too because the P-51 was able to plunge towards enemy airplanes from high altitude. Another key difference was the P-51 is very streamlined. Hence it was capable to fly much further than the Spitfire. These two differences let the P-51 Mustang fulfill its purpose: escort Allied bombers all the way to their targets in Germany. This allowed the bombings to be much more efficient and contributed to the defeat of the Nazis.

To get the P-51D Mustang on Linux use the `-aircraft=p51d` command line parameter.

To take off the P-51D Mustang in *FlightGear*, deploy one flaps step, pull and keep the yoke completely backwards, push the engine throttle to maximum and keep the left mouse button pressed to control the rudder and keep on the runway. Once you reach exactly 100 mph, suddenly push the rudder 1/3 of its total way to the right. Immediately release the left mouse button and push the yoke to rise the tail (don't push it too much, as the sooner the wheels leave the ground the better). From now on, keep the left mouse button released. Only make very short adjustments to the rudder. Let the plane rise from the runway and get to altitude at a speed of say 150 mph. Don't forget to retract the landing gear and the flaps.

Don't make too steep turns. You would loose control on the plane and crash.

To land, deploy full flaps and lower the landing gear from the start on. 130 mph speed seems fine, up to 140 mph. Make an approach from 1,000 feet altitude and a dive at a low angle, like for a jet. Once over the runway, shut the engine down completely (key{). Don't hover over the runway. Get the wheels rolling soon (like for a jet). Hold the left mouse button down to steer the plane using the rudder. Once the tail sinks in, briskly pull the yoke (left mouse button shortly released) to force the tail on the runway. Go on steering the plane using the rudder. Now the tail is firmly on the ground, use the brakes if you want.

8.13.5 How to take off and land the B-52 Stratofortress

The B-52F bomber implemented in *FlightGear* is a success. It is one of my favorite airplanes. I'm sorry it was conceived to terrify me. One single B-52 bomber can wipe out every main town of my country and rise a nightmare of sicknesses and children malformation for centuries. All B-52 bombers united can wipe out mankind and almost every kinds of plants and animals on Earth.

The differences between the virtual B-52F bomber and the Cessna 172p are these:

- The B-52F starts with the flaps deployed and the parking brakes set.

- There are only two flaps steps: retracted and deployed. When deployed they are only meant to make the wings lift more, not to brake. If you want to brake, you need the spoilers. They deploy on the upper side of the wings. Use the key **k** to deploy the spoilers and the key **j** to retract them. There are seven steps of spoilers.

- The main landing gear of the Cessna 172p is composed of two wheels, one on each side of the airplane. In order for these wheels to leave and touch the ground altogether, you need to keep the wings parallel with the ground. The main landing gear of the B-52F is composed of a set of wheels at the front and a set of wheels at the rear. This implies that in order for these wheels

to leave and touch the ground altogether, you need to keep the airplane body parallel with the ground.

This is my procedure to take off the virtual B-52F:

- *Push* the yoke $\frac{1}{3}$ of the total way.

- Push the engine throttle to maximum.

- Release the parking brakes (key **B**).

- Push down the left mouse button to control the rudder pedals and keep the airplane on the runway

- The whole runway length is needed till the B-52F rises from the ground (KSFO).

- Once the B-52F leaves the ground, around 190 knots seems appropriate to get to altitude.

- Retract the flaps and the landing gear.

To land, the B-52F's HUD offers that great airplane-shaped symbol I talked about in the section about jets. So you just have to put that symbol on the airplane threshold (a few pixels further seems optimal) and keep the runway start 2,5° below the ideal horizon line. 130 up to 140 knots seems a good landing speed. (Instead of the speed you can make use of the AOA indicator displayed on the schematic instrument panel (**P**).). Simply keep the AOA at 3°. I must confess I prefer to tune the speed rather than the AOA.) If the plane gets to the runway at 130 up to 140 knots, simply "let it smash" on the runway. Otherwise, if the speed is higher, make a rounding and a short hover. The brakes seem to be very effective **b**). They allow to stop the B-52F on roughly the same short runway length as the Cessna 172p.

Replays of the flights are a delight. They allow to check the plane body left the runway and landed back parallel with it. One of the points of view is situated inside the B-52F rear turret, which allows you to be your own passenger and to compare what you see with what you experienced as a passenger in airliners. The key **K** allows to visualize the airplane trajectory.

To cause an accident with the B-52 do this:

- Make a steep turn with a very strong bank; the wings nearly perpendicular to the ground.

- Try to get the plane back level. It will obey but very slowly. You will get aware that the turn will go on for a while and that you will turn further than your intended flight direction.

- Do something that accelerates the stabilization on some airplanes: push the rudder to an extreme, opposite to the current turn. This will suddenly make the airplane drop from the sky.

Chapter 9

A Cross Country Flight Tutorial

9.1   Introduction

Figure 9.1: Flying over the San Antonio Dam to Livermore

This tutorial simulates a cross-country flight from Reid-Hillview (KRHV) to Livermore (KLVK) under Visual Flight Rules (VFR). Both airports are included in the standard FlightGear package, so no additional scenery is required.

I'll assume that you are happy taking off, climbing, turning, descending and landing in FlightGear. If not, have a look at the tutorials listed above. This tutorial is designed to follow on from them and provide information on some of the slightly more complicated flight systems and procedures.

9.1.1   Disclaimer and Thanks

A quick disclaimer. I fly microlights rather than Cessnas in real life. Most of this information has been gleaned from various non-authoritive sources. If you find an error or misunderstanding, please let me know. Mail me at stuart_d_buchanan -at-yahoo.co.uk.

I'd like to thank the following people for helping make this tutorial accurate and readable: Benno Schulenberg, Sid Boyce, Vassilii Khachaturov, James Briggs.

9.2   Flight Planning

Before we begin, we need to plan our flight. Otherwise we'll be taking off not knowing whether to turn left or right.

First, have a look at the Sectional for the area. This is a map for flying showing airports, navigational aids, and obstructions. There are two scales of sectionals for VFR flight - the 1:500,000 sectionals themselves, and a number of 1:250,000 VFR Terminal Area Charts which cover particularly busy areas.

They are available from pilot shops, or on the web from various sources. You can access a Google-map style interface here:

http://www.runwayfinder.com/

Simple search for Reid-Hillview. An extract from the chart is shown in Figure 9.2.

If you want a map of the entire area showing exactly where the plane is, you can use Atlas. This is a moving-map program that connects to FlightGear. See Section 6.3 for details.

So, how are we going to fly from Reid-Hillview to Livermore?

We'll be taking off from runway 31R at KRHV. KRHV is the ICAO code for Reid-Hillview airport, and is shown in the FlightGear wizard. (It is marked on the sectional as RHV for historic reasons. To get the ICAO code, simply prefix a 'K'.)

The 31 indicates that the magnetic heading of the runway is around 310 degrees, and the R indicates that it's the runway on the right. As can be seen from the sectional, there are two parallel runways at KRHV. This is to handle the large amount of traffic that uses the airport. Each of the runways can be used in either direction. Runway 31 can be used from the other end as runway 13. So, the runways available are 13R, 13L, 31R, 31L. Taking off and landing is easier done into the wind, so when the wind is coming from the North West, runways 31L and 31L will be in use. The name of the runway is written in large letters at the beginning and is easily seen from the air.

Once we take off we'll head at 350 degrees magnetic towards Livermore (KLVK). We'll fly at about 3,500ft about sea-level. This puts us at least 500ft above any terrain or obstructions like radio masts on the way.

We'll fly over the Calaveras Reservoir then the San Antonio Reservoir. These are both large bodies of water and we can use them as navigation aids to ensure we stay on the right track.

Once we get about 10 miles out of Livermore (above the San Antonia Reservoir), we'll contact the Livermore Air Traffic Control (ATC) to find out where we should land. We'll then join the circuit and land.
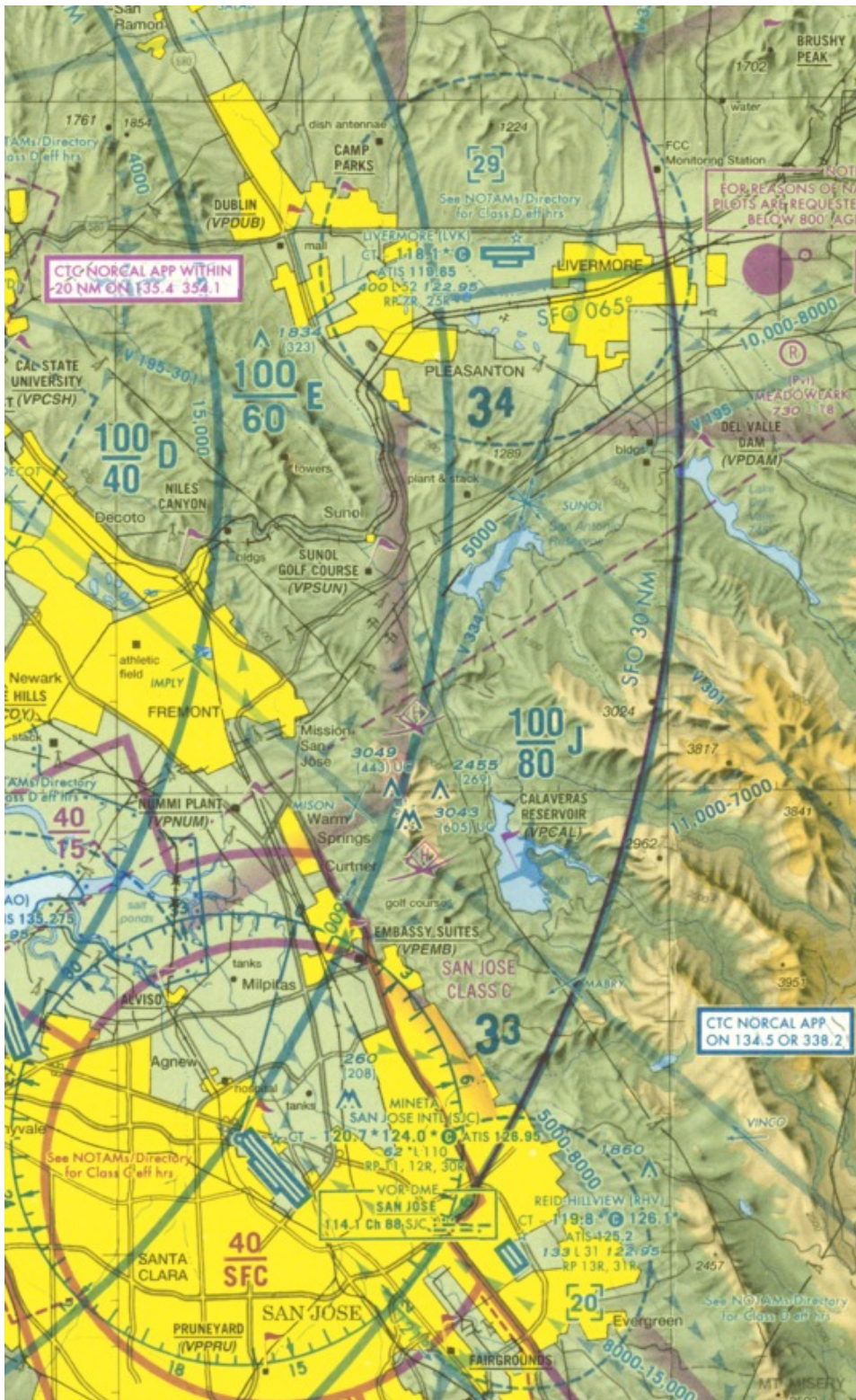
Figure 9.2: Sectional extract showing Reid-Hillview and Livermore airports

9.3   Getting Up

OK, we know where we're going and how we'll get there. Time to get started.

Start FlightGear using the Wizard (or command-line if you prefer). We want to use a C172P and take off from runway 31R at Reid-Hillview of Santa Clara County (KRHV). Dawn is a nice time to fly in California.

If you want, you can fly in the current weather at KRHV by clicking the Advanced button on the final screen of the Wizard, selecting Weather from the left-hand pane, selecting 'Fetch real weather' and clicking OK.

Figure 9.3: On the runway at KRHV

9.3.1   Pre-Flight

Before we take off, we need to pre-flight the aircraft. In the real world, this consists of walking around the aircraft to check nothing has fallen off, and checking we have enough fuel.

In our case, we'll take the opportunity to check the weather, set our altimeter and pre-set things that are easier to do when you're not flying.

The weather is obviously important when flying. We need to know if there is any sort of cross-wind that might affect take-off, at what altitude any clouds are (this is a VFR flight - so we need to stay well away from clouds at all times), and any wind that might blow us off course.

We also need to calibrate our altimeter. Altimeters calculate the current alititude indirectly by measuring air pressure, which decreases as you ascend. However, weather systems can affect the air pressure and lead to incorrect altimeter readings, which can be deadly if flying in mountains.

9.3.2   ATIS

Conveniently, airports broadcast the current sea-level pressure along with useful weather and airport information over the ATIS. This is a recorded message that is

broadcast over the radio. However, to listen to it, we need to tune the radio to the correct frequency.

The ATIS frequency is displayed on the sectional (look for 'ATIS' near the airport), but is also available from within FlightGear. To find out the frequencies for an airport (including the tower, ground and approach if appropriate), use the ATC/AI menu and select Frequencies. Then enter the ICAO code (KRHV) into the dialog box. The various frequencies associated with the airport are then displayed. Duplicates indicate that the airport uses multiple frequencies for that task, and you may use either.

Either way, the ATIS frequency for Reid-Hillview is 125.2MHz.

9.3.3 Radios

We now need to tune the radio. The radio is located in the Radio Stack to the right of the main instruments. There are actually two independent radio systems, 1 and 2. Each radio is split in two, with a communications (COMM) radio on the left, and a navigation (NAV) radio on the right. We want to tune COMM1 to the ATIS frequency.

Figure 9.4: The C172 communications stack with COMM1 highlighted

The radio has two frequencies, the active frequency, which is currently in use, and the standby frequency, which we tune to the frequency we wish to use next. The active frequency is shown on the left 5 digits, while the standby frequency is shown on the right. We change the standby frequency, then swap the two over, so the standby becomes active and the active standby. This way, we don't lose radio contact while tuning the radio.

To change the frequency, click on the grey knob below the standby frequency (highlighted in Figure 9.5), just to the right of the 'STBY'. Using the left mouse button changes the number after the decimal place, using the middle button changes the numbers before the decimal place. Click on the right side of the button to change the frequency up, and the left of the button to change the frequency down. Most of the FlightGear cockpit controls work this way. If you are having difficulty clicking on the correct place, press Ctrl-C to highlight the hot-spots for clicking.

Figure 9.5: COMM1 adjustment knob

Figure 9.6: COMM1 switch

Once you have changed the frequency to 125.2, press the white button between the words 'COMM' and 'STBY' to swap the active and standby frequencies (highlighted in Figure 9.6). After a second or so, you'll hear the ATIS information.

9.3.4 Altimeter and Compass

Figure 9.7: Altimeter calibration knob

Listen for the 'Altimeter' setting. If you are not using 'real weather', the value will be 2992, which is standard and already set on the plane. If you are using 'real weather', then the altimeter value is likely to be different. We therefore need to set the altimeter to the correct value. To do this, use the knob at the bottom left of the altimeter (circled in red in Figure 9.7), in the same way as you changed the radio frequency. This changes the value in the little window on the right of the altimeter, which is what you are trying to set, as well as the altitude displayed by the altimeter.

The other way to set the altimeter is to match it to the elevation above sea-level of the airport. The elevation is listed on the sectional. For KRHV it is 133ft. This means you can double-check the pressure value reported over ATIS.

Figure 9.8: Heading adjust knob

We will also take the opportunity to set the heading bug on the compass to 350 - our bearing from KRHV to KLVK. To do this, use the red button on the compass housing (highlighted in Figure 9.8), just as you've done before. Use the left mouse button for small adjustments, and middle mouse button to make big adjustments. The value of 350 is just anti-clockwise of the labeled value of N (North - 0 degrees).

Figure 9.9: Take-off from KRHV

9.3.5   Take-Off

OK, now we've done that we can actually take off!. In my case this usually involves weaving all over the runway, and swerving to the left once I've actually left the ground, but you'll probably have better control than me. Once above 1000ft, make a gentle turn to the right to a heading of 350 degrees. As we've set the heading bug, it will be easy to follow. We're aiming for a fairly prominent valley.

Continue climbing to 3,500 ft at around 500-700 fpm. Once you reach that altitude, reduce power, level off to level flight and trim appropriately. Check the power again and adjust so it's in the green arc of the RPM guage. We shouldn't run the engine at maximum RPM except during take-off.

9.4   Cruising

OK, we've taken off and are on our way to Livermore. Now we can make our life a bit easier by using the autopilot and our plane more fuel efficient by tuning the engine. We'll also want to check we're on-course

9.4.1   The Autopilot

We can make our life a bit easier by handing some control of the aircraft over to 'George' - the autopilot.

The autopilot panel is located towards the bottom of the radio stack (high-lighted in Figure 9.10). It is easily distinguishable as it has many more buttons than

Figure 9.10: The C172 Autopilot

the other components on the stack. It can work in a number of different modes, but we are only interested in one of them for this flight - HDG. As the names suggest, HDG will cause the autopilot to follow the heading bug on the compass, which we set earlier.

To set the autopilot, press the AP button to switch the autopilot on, then press the HDG button to activate heading mode. While the autopilot is switched on, it will use the trim controls to keep the plane on the heading. You can change the heading bug, and the autopilot will maneuver appropriately. However, the autopilot doesn't make any allowances for wind speed or direction, it only sets the heading of the airplane. If flying in a cross-wind, the plane may be pointed in one direction, but be travelling in quite another.

You should use the trim controls to keep a level flight. You can use the autopilot for this, but it is a bit more complicated.

Once the aircraft has settled down under the autopilot's control, we can pay more attention to the outside world and higher level tasks.

9.4.2 Navigation

Figure 9.11: The Calaveras Reservoir

As we noted above, we're going to be travelling over a couple of reservoirs. When you leveled off, the first (Calaveras) was probably right in front of you. You can use them to check your position on the map. If it looks like you're heading off course, twist the heading bug to compensate.

9.4.3   Mixture

Figure 9.12: The Calaveras Reservoir

As altitude increases, the air gets thinner and contains less oxygen. This means that less fuel can be burnt each engine cycle. The engine in the C172 is simple and doesn't automatically adjust the amount of fuel to compensate for this lack of oxygen. This results in an inefficient fuel burn and a reduction in power because the fuel-air mixture is too 'rich'. We can control the amount of fuel entering the engine every cycle using the mixture control. This is the red lever next to the throttle. By pulling it out, we 'lean' the mixture. We don't want the mixture too rich, nor too lean. Both these conditions don't produce as much power as we'd like. Nor do we want it perfect, because this causes the fuel-air to explode, rather than burn in a controlled manner, which is a quick way to trash an engine.
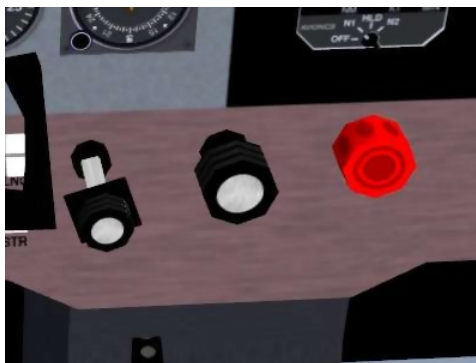
Figure 9.13: Mixture Control

The mixture is controlled by the red lever to the right of the yoke. You may need to pan your cockpit view to see it.

To pan the cockpit view, hold down the right mouse button Moving the mouse now pans the view. Once you can see the mixture lever clearly, release the right mouse button.

Figure 9.14: Fuel Flow and EGT guages

Pull the mixture lever out slowly (use Ctrl-C to see the hot spots), leaning the mixture. As you do so, you'll see various engine instruments (on the left of the panel) change. Fuel flow will go down (we're burning less fuel), EGT (Exhaust Gas Temperature) will go up (we're getting closer to a 'perfect mixture') and RPM will increase (we're producing more power). Pull the mixture lever out until you see the EGT go off the scale, then push it in a bit. We're now running slightly rich of peak. While at 3,500ft we don't need to lean much, at higher altitudes leaning the engine is critical for performance.

9.5 Getting Down

Once you reach the second reservoir (the San Antonio Reservoir), we need to start planning our descent and landing at Livermore. Landing is a lot more complicated than taking off, assuming you want to get down in one piece, so you may want to pause the simulator (press 'p') while reading this.

9.5.1 Air Traffic Control

In the Real World, we'd have been in contact with Air Traffic Control (ATC) continually, as the bay area is quite congested in the air as well as on the ground. ATC would probably provide us with a 'flight following' service, and would continually warn us about planes around us, helping to avoid any possible collisions. The FlightGear skies are generally clear of traffic, so we don't need a flight following service. If you want to change the amount of traffic in the sky, you can do so from the AI menu.

Livermore Airport is Towered (towered airports are drawn in blue on the sectional), so we will need to communicate with the tower to receive instructions on how and where to land.

Before that, we should listen to the ATIS, and re-adjust our altimeter, just in case anything has changed. This is quite unlikely on such a short flight, but if flying hundreds of milesm it might make a difference. To save time when tuning radios, you can access the Radio Settings dialog from the Equipment menu. The Livermore ATIS frequency is 119.65MHz.

An ATIS message also has a phonetic letter (Alpha, Bravo, . . . Zulu) to identify the message. This phonetic is changed each time the recorded message is updated. When first contacting a tower, the pilot mentions the identifier, so the tower can double-check the pilot has up to date information.

Besides the altitude and weather information, the ATIS will also say which runway is in use. This is useful for planning our landing. Normally, due to the prevalent Westerly wind, Livermore has runways 25R and 25L in use.

Once you've got the ATIS, tune the radio to Livermore Tower. The frequency is 118.1MHz. Depending on the level of AI traffic you have configured on your system, you may hear Livermore Tower talking to other aircraft that are landing or departing. This information is not played over the speakers, it is only displayed on the screen.

Once the frequency goes quiet, press the ' key. This will bring up the ATC menu. Click on the radio button on the left to select what you wish to say (you only have one option), then OK.

Your transmission will be displayed at the top of the screen. It will indicate who you are (type and tail number), where you are (e.g. 6 miles south), that you are landing, and the ATIS you have.

After a couple of seconds, Livermore Tower will respond, addressing you by name and telling you what runway to use, which pattern is in use and when to contact them, for example

> "Golf Foxtrot Sierra, Livermore Tower, Report left downwind runway two five left."

To understand what this means, we'll have to describe the Traffic Pattern.

9.5.2   The Traffic Pattern

With the number of aircraft flying around, there have to be standard procedures for take-off and landing, otherwise someone might try to land on-top of an aircraft taking off.

The Traffic Pattern is a standard route all aircraft must follow when near an airport, either taking off or landing. The traffic pattern has four stages (or 'legs'), shown in Figure 9.15. The 'downwind' mentioned above refers to one of these, the one with the number 3.
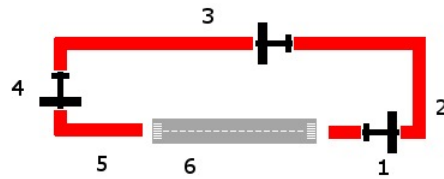
Figure 9.15: The Traffic Pattern

1. Aircraft take off from the runway and climb. If they are leaving the airport, they just continue climbing straight ahead until clear of the pattern and then do whatever they like. If they are returning to the runway (for example to practise landing), they continue climbing until they reach a couple of hundred feet below 'pattern altitude'. This varies from country to country, but is usually between 500ft and 1000ft Above Ground Level (AGL). This is called the *upwind* leg.

2. The pilot makes a 90 degree left-hand turn onto the *crosswind* leg. They continue their climb to 'pattern altitude' and level out.

3. After about 45 seconds to a minute on the crosswind leg, the pilot again makes a 90 degree left turn onto the *downwind* leg. Aircraft arriving from other airports join the pattern at this point, approaching from a 45 degree angle away from the runway.

4. When a mile or so past the end of the runway (a good guide is when the runway is 45 degrees behind you), the pilot turns 90 degrees again onto the *base* leg and begins the descent to the runway, dropping flaps as appropriate. A descent rate of about 500fpm is good.

5. After about 45 seconds the pilot turns again onto the *final* leg. It can be hard to estimate exactly when to perform this turn. Final adjustments for landing are made. I usually have to make small turns to align with the runway properly.

6. The aircraft lands. If the pilot is practising take-offs and landings, full power can be applied and flaps retracted for takeoff, and the aircraft can take off once more. This is known as 'touch-and-go'.

Most patterns at left-handed, i.e. all turns are to the left, as described above. Right-hand patterns also exist, and are marked as 'RP' on the sectional. ATC will also advise you what pattern is in use.

Figure 9.16: Sectional extract showing approaches to Livermore

9.5.3   Approach

We're approaching Livermore airport from the South, while the runways run East/West. Due to the prevailing Westerly wind, we'll usually be directed to either runway 25R or 25L. 25R uses a right-hand pattern, while 25L uses a left-hand pattern. Both the patterns are illustrated in Figure 9.16. Depending on the runway we've been assigned, we'll approach the airport in one of two ways. If we've been asked to land on runway 25R, we'll follow the blue line in the diagram. If we've been asked to land on runway 25L, we'll follow the green line.

We also need to reduce our altitude. We want to end up joining the pattern at pattern altitude, about 1,000ft above ground level (AGL). Livermore airport is at 400 ft above sea-level (ASL), so we need to descend to an altitude of 1400 ASL.

We want to begin our maneuvers well before we reach the airport. Otherwise we're likely to arrive too high, too fast, and probably coming from the wrong direction. Not the best start for a perfect landing :).

So, let's start descending immediately.

1. First switch off the autopilot by pressing the AP switch.

2. Return mixture to fully rich (pushed right in). If we were landing at a high airport, we'd just enrich the mixture slightly and re-adjust when we reached the pattern.

3. Apply carb-heat. This stops ice forming when the fuel and air mix before entering the cylinder, something that can often happen during descent in humid air. The carb-heat lever is located between the throttle and mixture. Pull it out to apply heat.

4. Reduce power quite a bit. Otherwise we might stress the airframe due to over-speeding.

5. Drop the nose slightly to start the descent.

6. Trim the aircraft.

Use your location relative to the airport and the two towns of Pleasanton and Livermore to navigate yourself to the pattern following the general guide above.

Once you're established on the downwind leg, you'll need to report to ATC again. Do this in the same way as before. They will then tell you where you are in the queue to land. 'Number 1' means there are no planes ahead of you, while 'Number 9' means you might want to go to a less busy airport! They'll also tell you who is ahead of you and where. For example 'Number 2 for landing, follow the Cessna on short final' means that there is a single aircraft in front of you that is currently on the final leg of the pattern. When they land and are clear of the runway, they'll tell ATC, who can then tell you 'Number 1 for landing'.

9.5.4 VASI

Figure 9.17: On Final at Livermore with VASI on the left

Once on final, you'll notice two sets of lights on the left of the runway (enhanced in Figure 9.17). This is the VASI and provides a nice visual clue as to whether you're too low or too high on approach. Each set of lights can either be white or red. White means too high, red means too low. White and red together means just perfect. On a Cessna approaching at 60kts, a descent rate of about 500fpm should be fine. If you are too high, just decrease power to increase your descent rate to 700fpm. If you are too low, increase power to decrease your descent rate to 200fpm.

9.5.5   Go Around
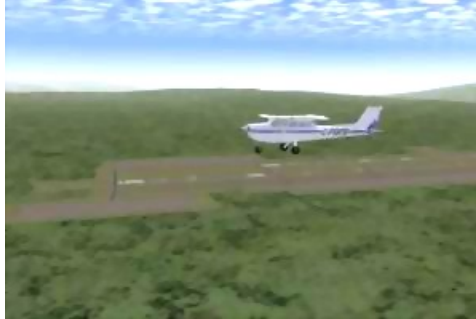
Figure 9.18: Missed approach at Livermore

If for some reason it looks like you're going to mess up the landing you can abort the landing and try again. This is called a 'Go Around'. To do this

1. Apply full power

2. Wait until you have a positive rate of climb - i.e. your altitude is increasing according to the altimeter.

3. Raise your flaps to 10 degrees (first-stage).

4. Tell ATC you are 'going around'

5. Climb to pattern height

6. If you aborted on final approach, continue over the runway to re-join the pattern on the crosswind leg. If on base, fly past the turn for final, then turn and fly parallel to the runway on the opposite side from downwind to rejoin on the crosswind leg.

7. Fly the complete pattern, telling ATC when you are on downwind, and try again.

9.5.6   Clearing the Runway

Once you're on the ground, you should taxi off the runway, then tell ATC you are clear. At high-altitude airports, you would lean the engine to avoid fouling the spark-plugs with an over-rich mixture. Find somewhere nice to park, shut down the engine by pulling mixture to full lean, then throttle off and magnetos to off (knob on the bottom left of the panel). Switch off the avionics master switch, tie down the aircraft, then go get that hamburger!

I hope this tutorial is of some use. If you have any comments, please let me know at stuart_d_buchanan {at} yahoo.co.uk.

Chapter 10

An IFR Cross Country Flight Tutorial

10.1 Introduction
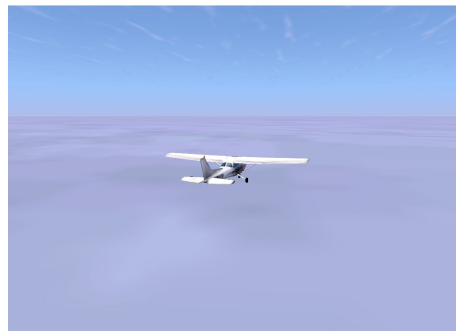
Figure 10.1: Flying over the San Antonio Dam to Livermore. I think.

In the cross country flight tutorial, you learned about VFR flight, and in the course of the flight you were introduced to most of the flight instruments in the C172p. Now we're going to do an Instrument Flight Rules (IFR) flight. In this flight you'll be introduced to the remaining instruments, learn a bit about IFR flight, and learn many, many TLAs (Three-Letter Acronyms).

We'll fly the same flight, from Reid-Hillview (KRHV), runway 31R, to Livermore (KLVK), runway 25R, only this time we'll do it in IFR conditions: a ceiling 200 feet above ground level, and 800 metre visibility. This tutorial assumes you've completed the cross country flight tutorial.

10.1.1   Disclaimers

This is not intended to teach you how to fly IFR. Rather, it is meant to give a flavour of what IFR flying is like, and remove the mystery of the panel instruments not covered by the cross country flight tutorial.

I'm not a pilot. Like the previous tutorial, this information has been gleaned from various non-authoritative sources. If you find an error or misunderstanding, please let me know. Mail me at bschack-flightgear -at- usa -dot- net.

This flight was flown using FlightGear 3.0. Newer or older versions of Flight-Gear might be slightly different.

10.2   Before Takeoff

We need to tell FlightGear about our flight conditions. There are different ways to set our "desired" weather, but we'll use the global weather menu. After launching FlightGear, click **Environment** ⇒ **Weather** to bring up the weather dialog. In the **Weather Conditions** list, select **CAT I minimum**.

This will give us a low ceiling and reduced visibility. Unfortunately, it will also give us rather stiff winds. If you don't want to deal with them, then you can easily turn off the winds:

- Click on **Weather Conditions** again, and select **Manual input**.

- In the METAR string at the bottom, change "15015KT" (15 knot winds coming from 150°) to "15000KT" (0 knot winds coming from 150°).

Hit **OK** to make FlightGear accept the changes and close the dialog.

Finally, I find that the reduced visibility situations are rendered best when atmospheric light scattering is turned off: click **View** ⇒ **Rendering Options** and make sure the **Atmospheric light scattering** box is unchecked.

10.2.1   Flight Planning

When you look out the window, you'll see something like Figure 10.2. Those clouds don't look very friendly, and it's hard to even see past the end of the runway. Maybe we should just *drive* there in the Cessna. We had been planning to practice ground steering anyway . . .

So how do you get from A to B when you can't see? There are a variety of ways that have evolved over the years, with various advantages and disadvantages. Our flight will use all of the navigation instruments the standard Cessna C172p has, just to give a taste of what's possible.

Our entire route, and the aids we'll be using, are shown in Figure 10.3. Our route is in green, the navigational aids blue and red. The route looks a bit crazy — in fact, you might wonder if we're *more* lost using our fancy equipment than just flying by the seat of our pants — but there is a method to the madness. Rather than

Figure 10.2: On runway 31R at KRHV

overwhelming you with details by explaining it all now, I'll explain it bit by bit as we go along.

10.2.2 VHF Omnidirectional Range

The first bit will involve VOR[1] (VHF (Very High Frequency) Omnidirectional Range) navigation, and will get us to a point about 5 nm (nautical miles) south of Livermore.

VOR stations are indicated on the sectional by a big bluish-green circle with compass markings around the outside. I've helped you by marking their centers with a big blue dot as well. Reid-Hillview is very close to one, San Jose, which you can see in Figure 10.3. Near the centre of the circle, in a bluish-green rectangle, is the station information. According to the station information, it's a VOR-DME station (I'll explain DME later), its name is San Jose, its frequency is 114.1 MHz (or Channel 88, which is an alternative way to say the same thing), and its identifier, or "ident", is SJC (which in Morse code is ··· ·−− −·−·).

To tune into a VOR station, we use one of the NAV receivers, which are paired with the COMM receivers (see Figure 10.4). And we navigate using the corresponding VOR gauge. We'll choose the NAV1 receiver (and VOR1 gauge) in this case (NAV2 would have worked just as well). Before setting the frequency, check out the VOR1 gauge. It should look like VOR1 on the left in Figure 10.5. The important thing is the red "NAV" flag. That means there's no VOR signal, so we

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[1]See http://en.wikipedia.org/wiki/VHF_omnidirectional_range for more information.
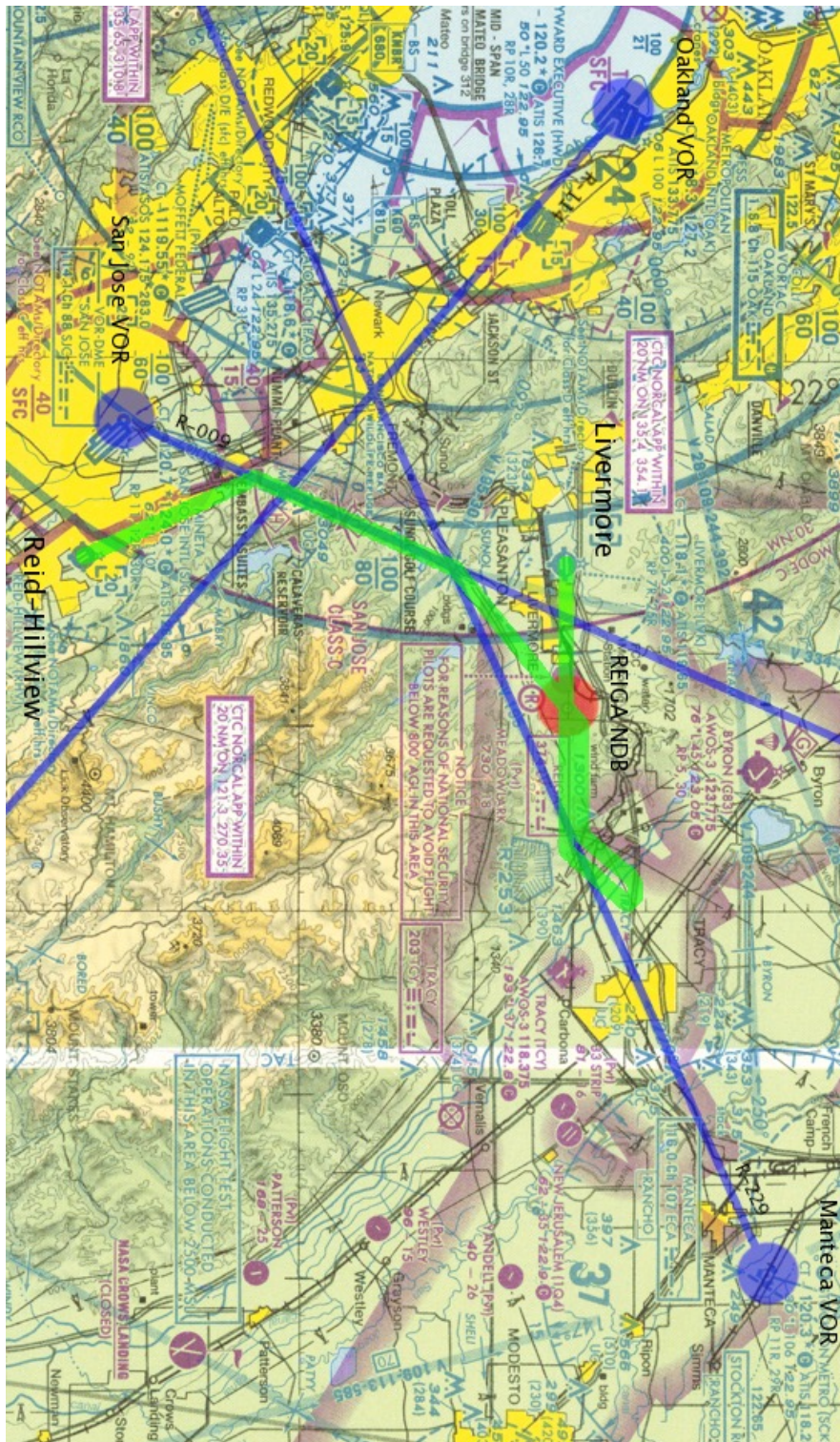
Figure 10.3: Green: our route, Blue: VORs and radials, Red: NDBs
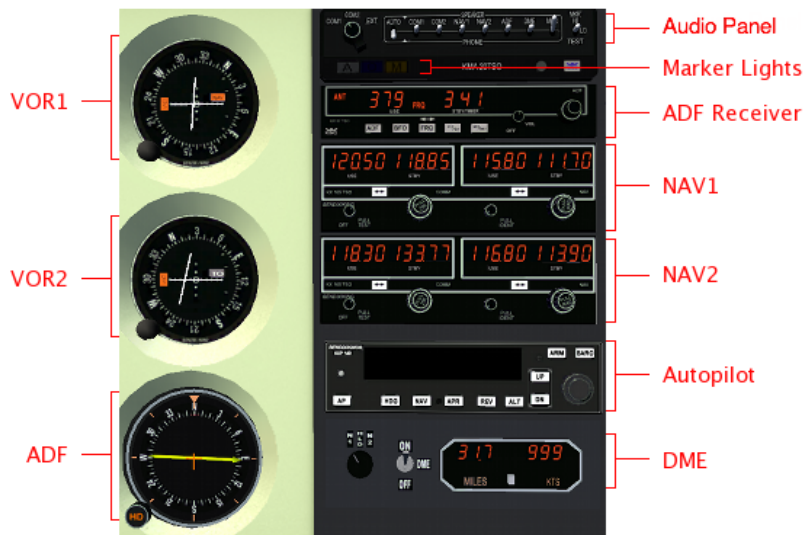
Figure 10.4: IFR navigation instruments

can't trust the gauge.

The NAV receiver has an active frequency, a standby frequency, and a tuning knob, just like the COMM receiver.[2] Tune it to 114.1, and press the swap button. NAV1 ⇒ 114.1[3] If you look at VOR1, you should notice that the red "NAV" flag has disappeared, to be replaced with a "TO" flag, as shown on the right of Figure 10.5. That means we're receiving a signal. But is it the correct one? What if we accidentally set the wrong frequency?

To confirm that we're tuned into the correct VOR, we listen for its ident. If you can't hear the ident, or if it doesn't match the chart, don't trust the needle. So far, you probably haven't heard a thing. Why? Check the audio panel (see Figure 10.4). You'll note there's a switch for all the instruments that produce useful sounds, and NAV1 is one of them. Flip the switch up (or down — it doesn't matter), and you should hear this: ··· ·––– –·–·.[4] Nice. Flip the switch back to the centre when

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[2]Operation of the COMM receivers was covered in the cross country flight tutorial.

[3]All important actions and events will be given in the margin. This should provide a nice summary of the flight, uncluttered by the verbiage of the text.

[4]Still can't hear it? Check the volume control on the NAV1 receiver. If that has no effect, click **File ⇒ Sound Configuration** and adjust the settings. If that doesn't work, check the volume on your computer. If that doesn't work, and you have external speakers, adjust the volume on the speakers. And if that doesn't work, check your ears.
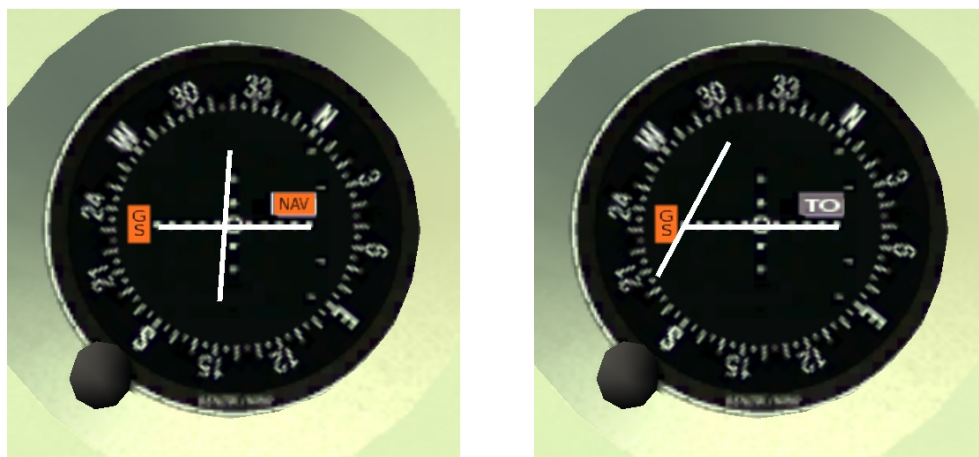
Figure 10.5: VOR1, before and after tuning

you get tired of listening to dots and dashes.

Back to VOR1. There's a knob on the lower left, called the OBS (Omni Bearing Selector). As the name vaguely suggests, it is used to select a bearing. If you turn it, you should see the vertical needle, called the CDI (Course Deviation Indicator) move.[5] Try to center the needle. It should center when the little arrow at the top points to somewhere around 277. That number, and the TO flag means: "Flying at a heading of *277°* will lead you directly *to* the station".

That's great, except, according to our route, we don't want to go *to* the station. We actually want to intercept the light blue line labelled "009°" (the "9 degree radial") coming *from* the station. How do we do that? Simple. Set the OBS to 9. When we fly across the radial, the needle will center, and the flag will say FROM. This tells us: "flying at a heading of *9°* will lead you directly away *from* the station", which is what we want. At that point we'll turn right to a heading of 9°.

VOR1 OBS ⇒ 009

One final thing — set the heading bug on the directional gyro to our current heading (about 310°).

Heading bug ⇒ 310

10.2.3 How High Are We Really?

One effect of our changing the weather conditions is that the barometric pressure is no longer the standard value of 29.92. Our altimeter needs to know the correct value, otherwise it will report the wrong altitude. This isn't critical at takeoff, but it can make a *huge* difference when descending through the clouds (can you say "controlled flight into terrain"?).

As described in the cross-country flight tutorial, we get the current barometric pressure via ATIS. To recap, click **AI ⇒ ATC Services in Range**, select our

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[5]The horizontal needle is used in ILS landings, which will be explained later.

airport, and look up the ATIS frequency (it should be 125.20 MHz). Dial this frequency into COMM1 or COMM2 (remembering to flip the appropriate switch on the audio panel), listen to the ATIS report, and set the altimeter to the given barometric pressure.

We are going to be using the autopilot (see Figures 10.4 and 10.6) to hold an altitude (more on that later), so it also needs to know the barometric pressure. To do so, click the BARO button on the autopilot. You should see "29.92" displayed — this is what the autopilot thinks the barometric pressure is. Before the "29.92" disappears (within about 3 seconds), rotate the big dial to change it to the correct value.

10.3 Takeoff

We're ready to take off. There are other preparations that we should have made, but again, in the interests of not overwhelming your brains, I'm only feeding you a bare minimum of information, and feeding it in trickles. This brings us to the most important control you have — the 'p' key. Use this often, especially when a new concept is introduced.

Okay. Take off, keeping a heading of 310° for now. Establish a steady rate of climb. We plan to climb to 4000 feet. There's just one problem though — those ugly-looking clouds are standing in our way.

Take off; climb on runway heading

10.4 In the Air

If this is your first attempt at IFR flight, you will find it impossible to fly once you enter the clouds. When you enter the clouds, you will be momentarily disconcerted by the lack of visual cues. "No matter," you then think. "I'll just keep things steady." In a few moments, though, you'll probably notice dials and needles spinning crazily, and without knowing it, you'll be flying upside down, or diving towards the ground, or stalling, or all three.

It takes practice to get used to flying without external visual clues, although it's a skill that you definitely *must* master if you want to fly IFR. For now though, we'll use "George", the autopilot, to make this part of flying easier.

10.4.1 George I

Once you've established a steady rate of climb and heading, engage the autopilot by pressing the AP button. You should see "ROL" displayed on the left to show that it's in "roll mode" — it is keeping the wings level. In the middle it will display "VS", to show it is in "vertical speed" mode — it is maintaining a constant vertical speed. On the right it will *momentarily* display that vertical speed (in feet per minute). Initially, the value is your vertical speed at the moment the autopilot is

Figure 10.6: Autopilot after engaging

Figure 10.7: Typical IFR scenery

turned on. In the case of Figure 10.6, the autopilot has set the vertical speed to 300 feet per minute.

When you engage the autopilot, CHECK THIS CAREFULLY. Sometimes the autopilot gets a very funny idea about what your current rate of climb is, like 1800 feet per minute. Our little Cessna cannot sustain this, and if the autopilot tries to maintain this (and it will), you will stall before you can say "Icarus". This is a bug, to be sure, and a bit annoying, but it is also a useful cautionary lesson — don't put blind faith in your equipment. Things fail. You have to monitor and cross-check your equipment, and be prepared to deal with problems.

We want a vertical speed of around 500 to 700 feet per minute. Hit the up and down (UP and DN) buttons to adjust the vertical speed to a nice value. Take into account the airspeed as well. We want a sustainable rate of climb.

Engage autopilot; set vertical speed; engage heading mode

Finally, once you're climbing nicely, hit the heading (HDG) button. On the display, "ROL" will change to "HDG", and the autopilot will turn the airplane to track the heading bug. Since you set the heading bug to the runway heading, and you took off straight ahead (didn't you?), it shouldn't turn much.

10.4.2   MISON Impossible

It's around 8 nm to the 009 radial intercept, so we've got a bit of time. Since there's no scenery to admire (eg, see Figure 10.7), we might as well prepare for the next phase of the flight.

Figure 10.8: Oakland VOR and 114 radial to MISON intersection

If you look along our route, just after we intercept the 009 radial and turn north, we pass by a point labelled MISON (see Figure 10.8 for a closeup of that section of the chart without my fat blue and green lines drawn on top. MISON is in the lower right). Just above and to the left of MISON are two crossed arrows. MISON is an intersection. We're actually going to pass east of MISON, but the radial passing roughly from northwest to southeast through MISON (and our route) is of interest to us. We're going to use it to monitor our progress.

Noting our passage of that radial isn't strictly necessary — we can just keep flying along the 009 radial from San Jose until we need to turn. But it's useful for two reasons: First, it's nice to know exactly where we are. Second, it confirms we are where we think we are. If we fly and fly and never cross the radial, alarm bells should start going off.

Looking at the sectional, we see that the radial is the 114 radial from the Oakland VORTAC (VOR TACAN, where TACAN stands for Tactical Air Navigation). Oakland's frequency is 116.8, and its ident is OAK (––– ·– –·–). NAV2 should

NAV2 ⇒ 116.8

already be tuned to Oakland, but if it isn't, do it now. Turn on NAV2 in the audio panel and make sure you're getting the correct ident.

We need to adjust the OBS, to tell VOR2 which radial we're interested in. Set

VOR2 OBS ⇒ 114

the OBS to 114.[6] See if you can guess whether the flag should read TO or FROM when we cross the 114 radial. And see if you can guess whether the needle will move from left to right or right to left as we cross the radial.

A final note: For our purposes, there's nothing magical about the 114 radial — we could have used 113, or 115, or 100, or 090. The reason I chose 114 is because there was a line on the map already drawn along the 114 radial, which saved me the trouble of drawing a line myself.

10.4.3   George II

As we continue towards the 009 radial intercept, let's look a bit more closely at the autopilot. First of all, if you aren't in the habit of trimming the airplane, you'll probably notice a flashing "PT" with an arrow on the autopilot. The autopilot is telling you to adjust the pitch trim. I tend to ignore it because, flying with a mouse, trimming is more trouble than it's worth. Those of you lucky people with yokes and joysticks and who find flashing lights annoying might want to trim to get rid of it.

Also, on the right there's a big knob, the altitude select knob, which we can use to dial in a target altitude. We're going to use it. Turn it until you see our desired cruising altitude, 4000 feet, displayed on the right. When you started turning it, "ALT ARM" should have appeared in the autopilot display (as in Figure 10.9).

Set autopilot altitude to 4000

This indicates that you've selected a target altitude. The autopilot will maintain the current rate of climb until reaching that altitude, at which point it will level off and change from vertical speed (VS) mode to altitude hold (ALT) mode. In altitude hold mode it maintains an altitude (in this case our target altitude of 4000 feet).[7] It will also politely beep 5 times when you cross 3000 feet to remind you that you're within 1000 feet the armed altitude.

Don't forget that the autopilot won't adjust the throttle, so when it levels out, the airplane (and engine) will speed up. You'll need to adjust the throttle to get a proper cruise.

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[6] If you get tired of clicking on the knobs, much of this can be done more easily using the **Equipment ⇒ Radio Settings** dialog.

[7] Of course, you don't really have to do this — you could just watch the altimeter, and when it gets to 4000 feet, reduce the vertical speed to 0, or press the ALT button to enter altitude hold mode. But by using the altitude select knob, we've demystified one more mystery button.

Figure 10.9: Autopilot with altitude armed

10.4.4 Staying the Course

At some point you'll intercept the 009 radial (the VOR1 needle will centre). Turn to a heading of 009. You can do this using the heading bug on the directional gyro if you're using the autopilot.

> Turn to 009° upon VOR1 intercept

Unless you're good or lucky, the needle probably won't be centered. We need to adjust our course. The CDI needle (the vertical needle on the VOR) tells us where to go. If it's to the left, that means the radial is to the left, so we need to go left. Ditto for right.

It's quite easy in theory, although in practice you may find that it's hard to keep the needle centered, and that you are slaloming down the radial. The key is to realize this: the *position* of the needle tells us where we *are*, the *motion* of the needle tells us what to *do*.

I'll explain. If the needle is to our left, then, yes, the radial is definitely to our left.[8] But if the needle is *moving* towards us, that means we're going to cross the radial, sooner or later, so our situation is improving, and we probably just need to wait for the needle to center. On the other hand, if the needle is *moving* away, we need to turn towards it to stop, and reverse, its motion.

Note that the amount we need to turn is difficult to guess correctly at first, so experiment. Try 10°. If the needle moves too fast, cut it down to 5° (ie, turn back 5°). If, on the other hand, the needle moves too slowly, double it to 20° (ie, add another 10°), and see what happens.

10.4.5 Yet More Cross-Checks

Cross-checking your position is always a good thing. The intersection with the Oakland 114 radial is one way. Ahead of that lies the SUNOL intersection. If you look closely, 5 separate radials join at the point, so we have an embarrassment of choices with regards to the intersecting radial. Because it will come in useful later, we're going to use the one coming in from the upper right. Another check of the sectional reveals that this is the 229 radial of the Manteca VORTAC, 116.0 MHz, ident ECA (· −·−· ·−).

> Cross OAK 114 radial

You should know the drill by now: Tune NAV2 to 116.0, set the OBS to 229, and check the ident to confirm the station.

> NAV2 ⇒ 116.0
> VOR2 OBS ⇒ 229

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[8]Unless you're heading in the opposite direction, but that's another story.

Meanwhile, let's introduce another piece of gear on the panel that will cross-check the SUNOL passage. Some VOR stations have a distance capability, called DME[9] (Distance Measuring Equipment). For example, San Jose does (remember it's a VOR-DME station), as do Oakland and Manteca (VORTACs have DME capabilities).

Using DME, you can find out how far you are, in straight-line distance, from the VOR station. In our scenario, the DME isn't necessary, but we'll use it anyway, just to see how it works, and to reconfirm our position.

The DME is the instrument below the autopilot (refer to Figure 10.4). Make sure it's turned on. The selector to the left of the on/off switch is probably set to N1, where "N1" means "listen to NAV1". Since NAV1 is tuned to San Jose, it's telling us the distance to the San Jose VOR-DME. Switch the DME to N2. It now shows us the distance to the Manteca VOR.

DME ⇒ N2

The DME shows you 3 things: the distance in nautical miles to the station, your speed towards or away from the station, and estimated time to the station at the current speed. Note that the distance is the direct distance from your plane to the station (called the "slant distance"), not the ground distance. Note as well that the speed is relative to the station, so unless you're flying directly to or from the station, it will probably be lower than your true groundspeed. For example, the speed from San Jose, which is directly behind us, should be greater than the speed towards Manteca, which is off to the right.

If we look up information about the SUNOL intersection,[10] it tells us that it is 33.35 nm (as measured by a DME receiver) from ECA on the 229.00 radial (that's what "ECAr229.00/33.35" means).

Now we have two ways to confirm the SUNOL intersection: The VOR2 needle will center, and the DME will read 33.4 or so. Note that the DME doesn't provide us with a very precise fix here because Manteca is at such an oblique angle. But it does give us a good warning of SUNOL's impending arrival. Moreover, if it has an unexpected value (like 30), it should raise a few alarm bells.

You may be wondering what "HLD" means (the setting between N1 and N2 on the DME). It stands for "hold", and means "retain the current frequency, regardless of whether NAV1 or NAV2 are retuned". For example, if we switch from N2 to HLD, the DME will continue to display (and update) information to Manteca. Even if we retune NAV2, the DME will remain tuned to Manteca. This is handy, because it basically represents a third independent receiver, and in IFR flight two receivers just never seem like enough.

10.5   Getting Down

We're getting close to SUNOL, flying along the 009 radial from San Jose, monitoring our position with the DME. At SUNOL we'll be less than 5 nm from Livermore,

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[9]See http://en.wikipedia.org/wiki/Distance_Measuring_Equipment for more information.
[10]For example, from http://www.airnav.com/airspace/fix/SUNOL.

somewhere down there in the clouds. Perhaps if we just descended to 700 feet or so (Livermore is at 400, the ceiling is at 750) and headed more or less directly north after SUNOL, we'd get there? A recipe for disaster my friend, and you know it.

10.5.1 Instrument Approach Procedures

As you recall from the previous tutorial, when flying VFR, you don't just point your airplane to the nearest runway to land. You need to fly a pattern. This helps you line up, and helps prevent planes from crashing into one another, which is a Good Thing.

Similarly with IFR landings. There's a procedure to follow. In fact, there are *procedures* to follow. Because of the complexity of landing in IFR conditions, there's no single procedure for all airports. You need to check for your particular airport. In fact, you usually need to check for your particular airport, runway, and navigation equipment.

Our airport is Livermore (KLVK). Let's check the information for that airport. Go to http://www.airnav.com/airport/KLVK to see what they've got. Down near the bottom, we have IAPs (Instrument Approach Procedures). There are two listed for runway 25R. One is an ILS (Instrument Landing System) approach, the other a GPS (Global Positioning System) approach. Our plane has no GPS, but it does have ILS capabilities (I'll explain ILS later), so we'll choose that.

Although Livermore only has two different instrument approach procedures, big airports have many many more. If you look at nearby San Francisco, you'll see they have a *slew* of procedures. There are ILS procedures, GPS procedures, LDA procedures, VOR procedures, . . . I wouldn't be surprised if they had a procedure for someone with a sextant and an hourglass in there. To learn IFR flight, you'll need to master all of them.

Back to Livermore. If you download the procedure, you'll see something like Figure 10.10 (except for the colour). It's pretty overwhelming at first — it compresses a lot of information in a small space. We'll ignore as much as we can, restricting ourselves to the three parts that have been coloured in. And we'll do those parts on a "need to know" basis — we'll only look at them when we really have to.

Where to start? At the beginning of course. An IAP will have one or more Initial Approach Fixes (IAFs). These are your entry points to the approach procedure and can be found in the "plan view", which I've coloured purple in Figure 10.10. Our IAP lists two, one in the middle and one on the right (see Figure 10.11 for a close-up).

An IAF is a *fix*, and a fix is an identifiable point in space. In fact, we've already encountered another kind of fix, namely a VOR intersection. Fixes are also usually named (eg, MISON, SUNOL). The IAF on the right is named TRACY, and consists of a radial, a distance, and an altitude. Specifically, it's 15 DME (15 nm as measured by a DME receiver) along the 229 radial from the ECA (ie, Manteca) VOR.
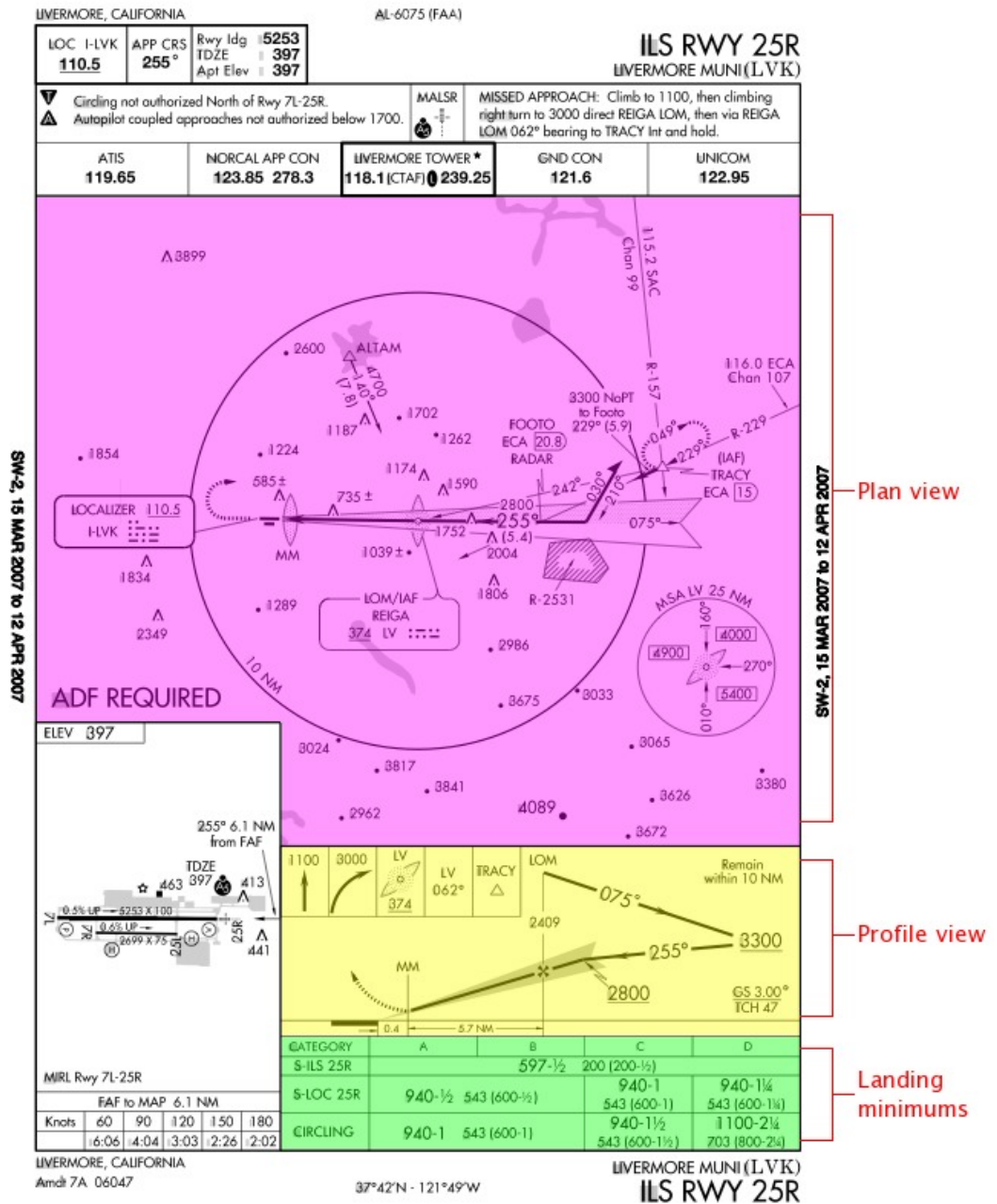
Figure 10.10: ILS approach plate for Livermore runway 25R
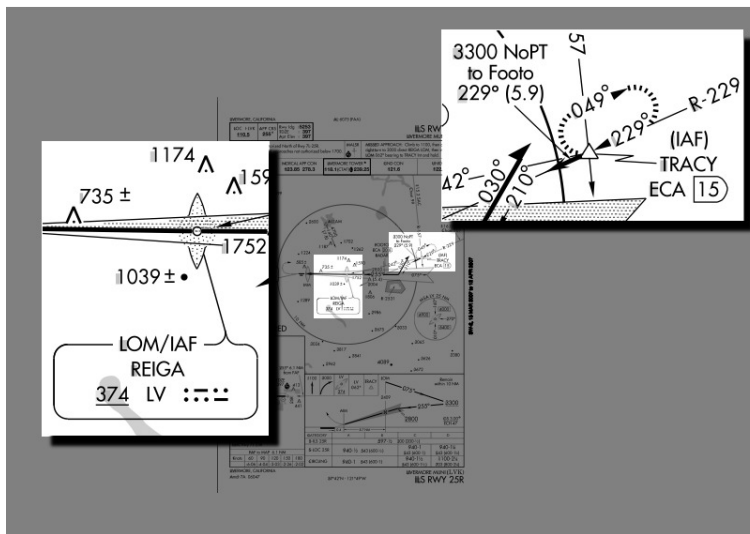
Figure 10.11: Initial approach fixes

10.5.2 Nondirectional Beacons

However, we're not going to use TRACY as our IAF. We're going to use the IAF in the middle, which is a marker (LOM stands for "Locator Outer Marker"). We'll worry about what an outer marker is later. For now let's concentrate on the locator part. The locator in an LOM is an NDB[11] (nondirectional beacon). It's a bit like a VOR, in that it can be used to determine your heading and navigate from place to place. Like a VOR, it has a name (REIGA, in this case), a frequency (374 kHz), and an ident (LV, or ·−·· ····− in Morse). NDBs also appear on sectionals, as fuzzy red circles with a small circle in the middle, with their identification information placed in a red box nearby. (see Figure 10.12 for a closeup. Don't confuse the NDB, which is fuzzy, with the solid red circle on the left, nor the circle below with the "R" inside).

An NDB station basically broadcasts a signal that says "I'm over here", and the receiver on the plane can receive that signal and tell you, the pilot, "the station is over there". You just need to tune the receiver and monitor the correct instruments. The receiver, labelled ADF (Automatic Direction Finder) Receiver, and the corresponding instrument, also labelled ADF, are shown in Figure 10.4.

To tune into REIGA, turn the tuning knob on the receiver until 374 is displayed as the standby (STDBY) frequency. As usual, use the middle mouse button for   ADF ⇒ 374
big changes (100 kHz in this case), and the left mouse button for small changes (1 kHz). Then hit the swap button (labelled "FRQ"). The 374 is now displayed as the selected (SEL) frequency. The needle on the ADF should swing around, eventually pointing ahead to the right, to REIGA. But it might not. Why? Because the receiver

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[11] See http://en.wikipedia.org/wiki/Non-directional_beacon for more information.
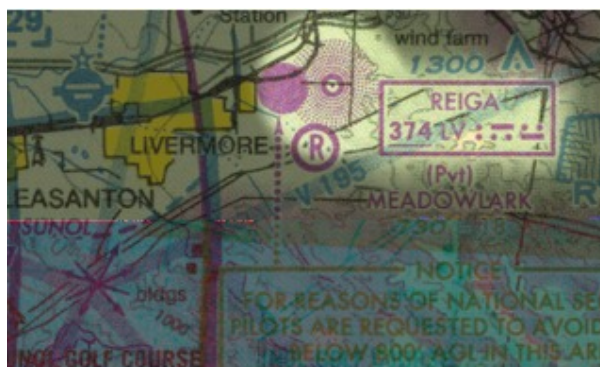
Figure 10.12: REIGA nondirectional beacon

might be in antenna mode (as show by the "ANT" in the upper-left portion of the display).[12] If it is in antenna mode, hit the ADF button so that "ADF" shows. Now the needle should swing to point to REIGA. Like VORs, to be sure we're really tuned into the right station, we need to hear the ident as well, so hit the ADF switch on the audio panel and check.

Notice there's no OBS to set for an ADF — the needle just points to the station, which is nice. This leads us to our first rule for ADFs:

ADF Rule 1: The needle points to the station.

Pretty simple. In fact, you may not think it merits a "rule", but it's important to emphasize the difference between ADFs and VORs. A VOR, remember, tracks a single radial, which you specify by turning the OBS. An ADF has a knob, and a identical-looking compass card, so it's tempting to believe it acts the same way. It doesn't. Turn the ADF heading knob (labelled "HD") and see what happens. The compass card moves, but the arrow doesn't. It just *points to the station*.

In our current situation, where we just want to fly to REIGA, that's all we need to know to use the ADF. If the needle points "over there", then we'll fly "over there", and eventually we'll pass over REIGA. However, for the sake of practice, and because it will be necessary later, I'm going to give the second rule for ADFs, which explains what the compass card is there for:

ADF Rule 2: *If* the compass card reflects our current heading, then
the needle gives the bearing *to* the station.

In other words, the compass card gives "over there" a number.

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[12]Antenna mode, by the way, is usually used to ident an NDB, because it gives better audio reception. While in antenna mode, however, the ADF will *not* point to the station — the needle will be parked pointing directly right.
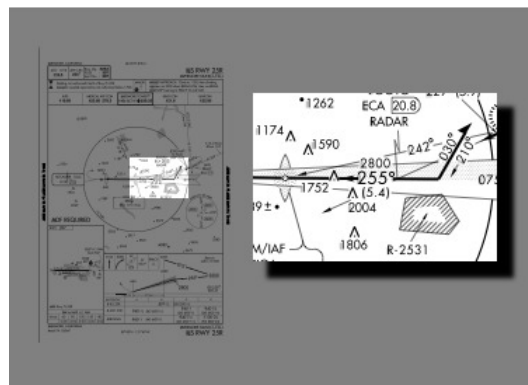
Figure 10.13: Livermore ILS procedure turn

Now we're ready to head to REIGA. Rotate the ADF heading knob until our current heading is at the top (basically, the ADF should match the directional gyro). When we pass the SUNOL intersection, look at the ADF needle, and set the DG bug to that heading (I assume you're using the autopilot. If not, just turn to that heading). At the end of the turn, the ADF needle should point straight ahead. And if it doesn't, adjust your heading so that it does.[13]

Cross SUNOL; turn to REIGA

By the way, the closer you get to REIGA, the more sensitive the needle becomes to changes in your heading. Don't go crazy trying to keep the needle centered as you get close. Maintain a steady heading, and get ready for the . . .

10.5.3 Procedure Turn

So, once we hit REIGA, do we just turn left and head down to the runway? Ah, if only life were so simple. No, we turn right, *away* from the airport, and do a *procedure turn*. We know there's a procedure turn because of the barbed arrow in the plan view (see Figure 10.13). As you can see if you follow the arrow, we need to fly away, on a heading of 075°, then turn left 45° to a heading of 030°. We do a U-turn (to the right, *away* from the airport — that's one of the rules about procedure turns) to come back at 210°, then a 45° right turn to 255°, heading straight towards the runway. All of this turning gives us time to set ourselves correctly on course, at the right altitude, to land on 25R.

Hmmm. I mentioned "right altitude", but how do we know that is? That's down below, in the profile view (the yellow part of Figure 10.10). You can see that at the top is the LOM, our IAF. Now follow the arrows. After the IAF, we head out at 075°. During the procedure turn we can descend to 3300 feet, but *no lower* (that's what the line *under* the 3300 means). After we finish our procedure turn

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[13]Which is actually bad technique in the presence of a crosswind, but I'm ignoring the wind to simplify the tutorial.

Figure 10.14: ADF with timer running

and are heading back at 255°, we can descend to 2800 feet, but *no lower*, until we intercept the glide slope.

One thing the instrument approach procedure does *not* tell you is the length of the procedure turn. The only constraint is that you must not fly more than 10 nm away from the NDB. You'll notice there's a 10 nm circle drawn around it in the plan view, and a note in the profile view saying "Remain within 10 NM". They're not kidding. So, since we fly at around 110 knots, two minutes on each leg is reasonable — two minutes at 075°, and two minutes at 030°. On the way back we don't care about times — we just want to intercept 255°.

So, after we pass REIGA, turn right to 075°. Our ADF receiver has a built-in timer, so we'll use that to time our two-minute leg. Hit the "FLT/ET" (flight time/elapsed time) button. The "FRQ" in the middle of the display will disappear, "FLT" will appear on the right, and the standby frequency will be replaced by a time. This is the total flight time, and cannot be changed, except by cycling the power. Hit "FLT/ET" again. Now you'll see "ET" displayed, and a time, probably the same as the flight time. To reset the elapsed time, hit the next switch, labelled "SET/RST". The timer should reset to 0, then start counting up (see Figure 10.14).[14] In elapsed time mode, each time you hit "SET/RST", the time resets to 0. If you want to see the standby frequency again, hit "FRQ" once. The timers will continue to run.

10.5.4   Chasing the Needle

When we approached REIGA, we weren't particularly concerned about our course — we just aimed for REIGA. Now, however, our course is important. We want to be flying directly away from REIGA *on a course of 075°*.

Cross   REIGA;   fly at 075° away from REIGA for two minutes

Now, in an ideal world, after we turned to 075°, the ADF needle would be pointed directly behind you (ie, we'd be on course). Probably it isn't, so we need to adjust our course. The key to adjusting our course is ADF Rule 2. If we've set the compass card correctly, then the needle shows us the current NDB bearing. If we turn and fly until we intercept the 255 bearing, then turn to 075°, we'll be right on course.

Figure 10.15 shows what I mean. In the figure, the plane, flying along the

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[14]The timer can also be set to count down from a time you specify — except that feature has not yet been implemented.
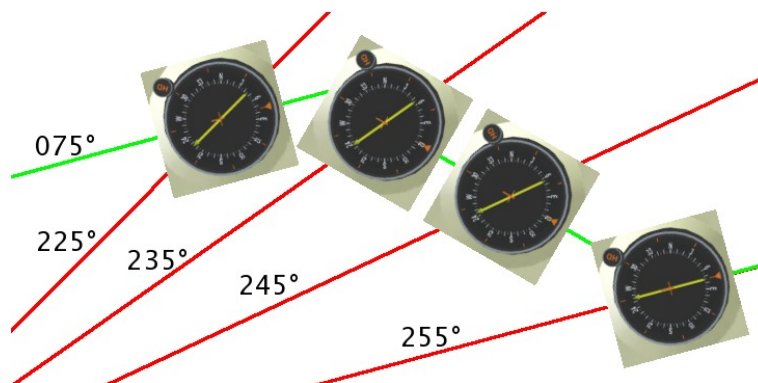
Figure 10.15: Getting back on course

green line, is initially off course.[15] The heading is correct, 075°, but the station is at 225°, not 255°. To correct this, we turn right (remembering to adjust the ADF compass card to match our new heading). As we fly on this new heading, we get closer to the correct position, crossing the 235 and 245 bearings (shown in red). Finally, when we the ADF needle points to 255°, we turn left to 075°, and readjust the ADF compass card.[16] We are now on course.

Of course, even when you get back on track, that won't be the end of the story. Your airplane drifts; your mind drifts; your compass drifts; the wind pushes you around. What you find is that you will be constantly making little corrections. That's okay, as long as we're close. And anyway, before long (2 minutes actually), we'll turn left 45° to 030° as part of our procedure turn, at which point we'll just ignore the NDB anyway. Sigh. All that effort for just 2 minutes. Hardly seems worth it.

10.5.5 FOOTO Time

While you're flying outbound, take an occasional look at VOR2, tuned to Manteca, and the DME. Assuming the OBS is still at 229, and the DME still tuned to N2, at some point the needle should center, meaning you've crossed the 229 radial, and, if you're on course, at the same time the DME should read 20.8. How do I know that? If you look at the approach plate (Figure 10.10), you'll notice an intersection, named FOOTO. FOOTO is on the approach, and is defined to be 20.8 DME from ECA. Although this intersection is not strictly necessary for us, it comes for free, and provides good confirmation of our position both outbound and, later, inbound.

Depending on how fast you're flying, you'll probably pass FOOTO close to the

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[15] *Way* off course, actually. I've exaggerated the angles to make the explanation clearer.

[16] You might be thinking "Wouldn't it be nice if there was an ADF where the compass card rotated automatically?" Well, such an ADF does exist, and it comes with its own acronym — RMI (Radio Magnetic Indicator).

time your two minutes at 075° are up. At the end of two minutes, turn left 45° to 030°. Reset the timer, and fly for another two minutes on this heading.

10.5.6   George III

Turn left to 030°; fly for two minutes while descending to 3300

This leg is relatively uneventful, so we'll take advantage of the lull in the action to descend to 3300. Before descending, check the KLVK ATIS (it should be 119.65 MHz) and make sure your altimeter is correct.

Assuming you're using the autopilot, you will need to do a few things to descend:

1. If you're in altitude hold (ALT) mode, you need to get back into vertical speed (VS) mode. Press the ALT button — the "ALT" in the middle of the display should change to "VS", and your current vertical speed (probably 0) should be displayed momentarily on the right.

2. Click the DN button until you get a vertical speed of -500 feet per minute.

3. If you want to set the target altitude, like before, rotate the big knob on the right until "3300" shows up on the right side of the display. "ALT ARM" should appear on the bottom.

Note that if you're using the autopilot to descend, it will just push the nose down, like a bad pilot, so the airplane will speed up. We want to go down, but we don't want to speed up, so we need to reduce engine RPMs to keep the speed at 110 knots. Later, when you level off at 3300 feet, you'll have to increase power again.

If you're flying manually, then you just need to adjust the engine to get the descent rate you want — the plane should stay magically at 110 knots if it's already trimmed for 110.

10.5.7   ILS Landings

While descending, we also need to start considering how we're going to intercept 255° on the way back and follow it down to the runway. You might think we're going to use the NDB like we did on the outbound leg, but at this point, the NDB is not good enough. This is an ILS landing, a so-called "precision" landing, and an NDB is just not precise enough. It can get us close to the runway, but not close enough.

So, we're going to switch over to our ILS system. It is much more accurate horizontally. As well, it offers vertical guidance, something which the NDB does not give at all. And hey, it also gives you something else to learn in our few remaining minutes so that you don't get bored.

As with NDB and VOR navigation, the ILS system[17] has a transmitter (or *transmitters* — a localizer *and* a glide slope) on the ground, and a receiver and a

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[17]See http://en.wikipedia.org/wiki/Instrument_Landing_System for more information.
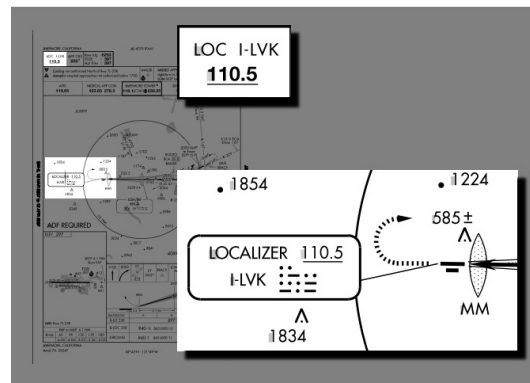
Figure 10.16: Livermore 25R localizer

gauge in the aircraft. The receiver, it turns out, is just a NAV receiver, of which we have two. The gauge is like a VOR indicator, but it has an added glide slope indicator, which is a horizontal (you hope) needle. Like a VOR, the vertical needle shows whether you're left or right. The horizontal needle shows whether you're high or low. Our ILS gauge is our old friend VOR1.

As you might have guessed, the localizer has a frequency and ident associated with it (there's no need to tune the glide slope separately. If you tune the localizer, you've tuned the glide slope). This is shown on the approach plate in two places: at the top left corner, and in the plan view by the runway (see Figure 10.16). As we can see, the frequency is 110.5 MHz, and the ident is I-LVK (·· ·—·· ···— —·—).

If you look at VOR1 now, it should be showing a red "GS" flag (this can be seen in Figure 10.5). This indicates that there is no glideslope signal. Now tune NAV1 to 110.5. The red "GS" flag should disappear. Check for the ident. Sounds lovely, doesn't it? That localizer is going to save your bacon and get you out of this interminable soup. When you tuned into the localizer, you'll also have noticed the ILS needles move. And the OBS? Well, it's useless. Try moving it. No matter how you turn it, the needles don't move in response. That's by design. A localizer is basically a VOR with *one* radial, the approach heading. We don't care about any others, so we don't need an OBS to declare interest in any others. However, it does serve as a useful reminder, so move the OBS to 255, our desired heading.

NAV1 ⇒ 110.5

VOR1 OBS ⇒ 255

10.5.8 Intercepting the Localizer

We're now ready to intercept the ILS localizer. When the two minutes on the 030° leg have passed, make your U-turn to the right to 210°. Soon after you complete your turn, the vertical (localizer) needle on the ILS will begin to move. And it will move *fast*, much faster than the ADF and VOR needles did. A localizer is 4 times as sensitive as a VOR, relatively small movements of the aircraft make big changes in the needles. You'll probably overshoot, but don't worry, because we

Turn right 180° to 210°

Intercept localizer

have around 5 or 10 minutes to get things straightened out.

Just remember: don't chase the needles. That mantra is now more important than ever. Those needles are sensitive — if you just turn left when the localizer needle is to the left and right when it's to the right, you'll be flying like a drunken sailor. If you're lucky, the runway will be passing underneath you as you swing across the track for the umpteenth time. Luck, though, is something we should not be relying on. Determine on how the needles are moving before making your move.

Now that you're heading back inbound at 255°, slow to 75 knots, drop a notch of flaps, and descend to 2800 feet (but no lower). And check for the inbound passage of FOOTO to confirm your position. And pat your head and rub your stomach.

Slow to 75 knots; drop a notch of flaps; descend to 2800

10.5.9 Intercepting the Glide Slope

As we fly towards the runway, don't forget to look at the horizontal needle, the glide-slope needle. When we intercepted the localizer, it should have been high above us, because we were actually under the glide slope. As we levelled out at 2800, the glide slope started coming "down" to us. Eventually, you should see the needle start to move down. When the needle is horizontal, that means you're on the glide slope.[18] And, soon after we intercept the glide slope, we should pass over the outer marker. Several things will happen more or less simultaneously, all of which confirm your position:

1. You'll hear a continuous series of dashes.

2. The blue light labelled "O" above COMM1 will flash.

3. The ADF needle will swing around.

Once on the glideslope, we need to start descending. What's a good rate? It depends on our groundspeed. In our case, we're going at 75 knots (there's almost no wind, so our airspeed and groundspeed are the same), and it turns out that we need to descend at around 400 feet per minute. With the autopilot, that's pretty easy — just dial in -400, and you're set (but remember to reduce power to keep our speed at 75 knots, or you'll hit the runway going pretty fast, and be prepared to adjust things if you drift above or below the glide slope).

Intercept glideslope; cross outer marker; drop second notch of flaps

Without the autopilot, it's also pretty easy — just reduce power. How much? In this case, with our plane, to around 1700 RPM. Again, it depends on many things — plane, elevation, winds, weight, . . . , so you'll have to adjust things if you see the glide-slope needle start to move up or down. Like the localizer needle though,

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[18]Maybe. There can be false glideslopes, and FlightGear models these, so we have to make sure we're on the real one. One purpose of the procedure turn is to get you in the correct position, at the correct altitude, to intercept the true glideslope.

... (are you ready?) DON'T CHASE IT. Watch how it's moving, then make your adjustment.

Since we're on final approach, you might want to drop a second notch of flaps. This will affect your trim, and you'll have to adjust power a bit as well.

10.5.10   Touchdown, Almost

After all the excitement of the procedure turn, it will seem like a long way down to the runway from the outer marker. There's not much to do but stare at those needles. In fact, you'll probably stare at them like you've never stared at them before. Take a look around at the other gauges too, though — they have useful things to tell you. Is our airspeed okay? We don't want to stall. RPMs about right? If flying manually, you'll want to constantly check the attitude indicator and directional gyro. This being a simulator, we don't have to worry about oil pressure and engine temperature, but you might want to glance over there anyway, just to get into the habit. And I hope you've done things like set the mixture to full rich (you did lean it out while cruising, didn't you?). If you want, you can lower the flaps completely as you get closer.

10.5.11   A Confession

I've actually made you do more work than you have to. We've been using the autopilot as a fancy steering wheel, but it's capable of more than that. You may have noticed that the autopilot has some buttons I haven't explained — NAV, APR, and REV. Well, using those buttons, the autopilot can:

NAV: Track a VOR radial.

APR: Do a direct ILS approach, tracking both the localizer *and* the glideslope.

REV: Intercept the ILS before the procedure turn (ie, head *away* from the localizer.

So, in fact, even more of the work you've done could have been done by the autopilot. After takeoff, you could have asked it to track the 009 radial from SJC all the way to SUNOL in NAV mode; at SUNOL, you could have asked it to fly the "back-course approach" from I-LVK in REV mode; done the procedure turn in HDG mode; finally, tracked the localizer and glideslope in APR mode.

However, I didn't give you this information for two reasons. First, flying by hand (even with the autopilot gently holding your hand, as we've been doing) gives you a better idea of what's happening. Second, the autopilot doesn't behave quite as the official manual says it should for some of these functions — best stick to the features that are known to work well.

10.5.12   Touchdown, Not

Although ILS approaches can get us close to the runway, closer than VFR, NDB, or VOR approaches can, we still need *some* visibility to land,[19] so we need a way to decide if landing is possible or not. That's what the landing minimums section of the procedure plate is for (coloured green in Figure 10.10). In the category labelled "S-ILS 25R" (that's us), you'll see "597-1/2 200(200-1/2)". This tells us that we can track the glide slope down to an altitude of 597 feet (200 feet above the runway). At 597 feet we make our decision — if we can't see the runway, then we have to execute a missed approach. 597 feet is our *decision height* (DH).

In addition to the altimeter, this particular approach also has another indication that we're close — a middle marker (MM). This marker will sound — in this case, a dot dash series — and the yellow light labelled "M" above COMM1 will flash. Passage over the middle marker should coincide with reaching decision height.[20]

So, what if you can't see the runway at decision height? As you might have expected, just as you can't land willy-nilly, you can't just go around willy-nilly. There's a Procedure. A Missed Approach Procedure. This is shown in several places on the approach plate (see Figure 10.17): At the top, where it says "MISSED APPROACH", in the plan view, where you can see a dashed arrow coming off the end of the runway and a dashed oval on the right, and in the profile view, where a series of boxes shows graphically what to do. In our case, these all tell us to:

1. Climb straight ahead to 1100 feet

2. Make a climbing right turn to 3000 feet

3. Fly to REIGA

4. Fly outbound from REIGA at 062°

5. Fly a holding pattern at the TRACY intersection

The holding pattern, as you might have guessed, is a place where you can "park" while sorting things out, and has its own set of procedures and techniques which we won't go into here, because . . .

10.5.13   Touchdown

In our ideal simulator world, you probably won't have to execute a missed approach. Assuming you stayed on the glide slope, you should have popped out of the murk at the decision height, and with 800 metre visibility, the runway should

Sight runway; disengage autopilot; cross middle marker

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[19]Well, unless it's a Category IIIC ILS approach.

[20]As you may have guessed, the remaining light — white, and labelled "A" — indicates passage of the inner marker. Our approach doesn't have one, but San Fransisco's runway 28R does. While passing over it, you should hear a rapid, high-pitched series of dots. Why is it labelled "A" and not "I"? Because in ancient times, it was also used to identify passage over "airway" markers along radio range tracks.

MISSED APPROACH: Climb to 1100, then climbing right turn to 3000 direct REIGA LOM, then via REIGA LOM 062° bearing to TRACY Int and hold.
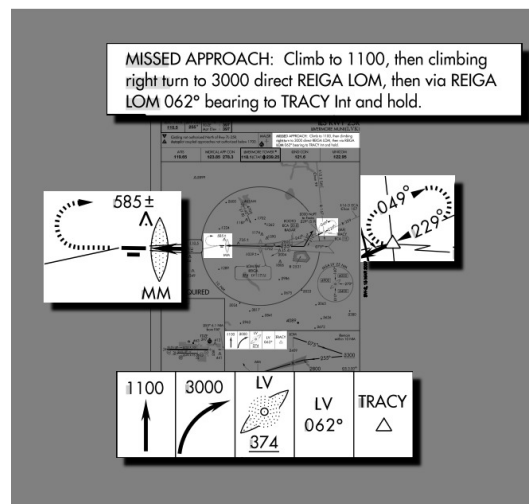
Figure 10.17: Missed approach procedure

have been in view soon after. With the runway in sight, you could then turn wildly to get on course[21] (it's very hard to be lined up perfectly) and land "normally" (which for me involves a lot of bouncing around and cursing). Park the plane, then stagger out of the cockpit and have another hamburger!

Land; eat hamburger

10.6 Epilogue

That was a lot of information in a short time, a rather brutal introduction to ILS flying. Hopefully, instead of turning you off, it has whetted your appetite for more, because there *is* more. Some of the major issues I've ignored are:

Wind This is a big one. Flying IFR in a crosswind affects everything you do, and you need to be aware of it or your navigation will suffer.

Flying without the autopilot George tries his best, but he's not completely trustworthy. You have to be prepared to go it alone.

DG precession The directional gyro in the c172p is not perfect. Over time, the values it gives you are less and less reliable — it *precesses*. It needs to be periodically calibrated against the compass (using the OBS knob on the DG to adjust it).

IFR charts We used sectionals, which are really intended for VFR flight. There are a whole set of charts devoted exclusively to IFR flight.

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[21]Remembering, of course, to disengage the autopilot.

Figure 10.18: On course, runway in view. We're going to live!

ATC The other people out there need to know what you're doing. As well, they'll probably tell you what to do, including to ignore the approach plate you so fastidiously studied.

SIDs/DPs, Airways, and STARs This tutorial introduced IAPs, which are standard ways to make approaches. In IFR flight, there are standard ways to *leave* airports (Standard Instrument Departures, *SIDs*, or Departure Procedures, *DPs*), standard ways to travel *between* airports (airways), and standard ways to go from airways to IAPs (Standard Terminal Arrival Routes, *STARs*).

Holding Patterns Most missed approaches end in a holding pattern somewhere, so you'd better know how to fly them.

GPS Our Cessna doesn't have a GPS, but nowadays most small planes do, and GPS is rapidly replacing radio-based navaids.

If you want to learn more, try the following resources:

- *Flight Simulator Navigation*, written by Charles Wood. It covers everything from basic navigation to ILS approaches, with lots of examples and practice flights to improve your skills. Everything is linked together by an entertaining storyline in which you are the pilot for a fictional charter service.

  Two caveats, though. First, it is Microsoft Flight Simulator-based, so you'll have to translate into "FlightGear-ese" as appropriate. Second, it is a bit out of date, and things in the real world have changed since it was written. NDB

beacons have been decommissioned, new approaches have replaced old ones — even an airport has disappeared (!). Treat this as a learning opportunity. You'll get better at finding more up to date information, and learn not to blindly trust your charts, just as you have learned not to blindly trust your instruments.

- If you're *really* keen and want to hear it straight from the horse's mouth, there's the official *FAA Instrument Flying Handbook*. It's big and detailed, and there's *no* interesting storyline in which you're a pilot for a fictional charter service. More documents can be found at their *Aviation Handbooks & Manuals* page.

- If you'd like practice deciphering what the instruments are telling you, without the bother flying (or even virtual flying), you can try *luizmonteiro.com*, which has Flash tutorials of various instruments, including a VOR and an ADF.

- Another simulated instrument site is *Tim's Air Navigation Simulator*. It has a Java applet that simulates a plane flying in the vicinity of two navaids. The simulation allows you to use different kinds of instruments and navaids, so you can see their behaviour, and the advantages and disadvantages of each.

- If it's navigation information you're after, an excellent site is *AirNav.Com*, which I've used extensively in the course of this tutorial. It has detailed airport, navaid, and fix information, and links to IAPs. Unfortunately, the information is only for the USA.

- Another source of airport and navaid information is *World Aero Data*. Its information isn't as detailed as AirNav's, but it is international.

- *FlightSim.Com* has a very informative series of articles entitled "How To ... Use Approach Plates". It starts with a *very, very* dense tutorial on how to read an approach plate, then follows with a set of approaches at Kodiak, Alaska. These are an excellent supplement to the approaches given in Charles Wood's *Flight Simulator Navigation* (see above).

  Most interesting, though, is section two — "Dangerous Approaches." Approaches at six airports around the world, from Penticton, BC to Kathmandu, Nepal, are described. Fly them if you dare!

  Warning — the series is even more Microsoft Flight Simulator-centric than Charles Wood's, and some of it is out of date (some outside links are broken, and some of the approaches have changed).

- Also from *FlightSim.Com* is "Golden Argosy", a description of a flight from New York to Rome by Tony Vallillo, an American Airlines 767 captain. It gives some interesting information about navigation that doesn't appear in the other sites mentioned here, such as the North Atlantic Tracks. However,

its main appeal is that it gives a good answer to the question "What's it *really* like to be a pilot?" The author's love of flying is evident throughout the article.

- For those who are interested in the ATC side of things, and want information from an authoritative source, check out Michael Oxner's "Aviation Topic of the Week", a series of articles about flying "in many types of airspaces in many situations." Michael Oxner is a professional controller and private pilot who obviously can't get enough of airplanes, because in his spare time he's also an on-line controller with VatSim. Particularly interesting are a set of articles describing a complete IFR flight and a complete VFR flight.

Chapter 11

A Helicopter Tutorial

11.1 Preface

First: in principle everything that applies to real helicopters, applies to *FlightGear*. Fundamental maneuvers are well described here:

http://www.cybercom.net/~copters/pilot/maneuvers.html Some details are simplified in *FlightGear*, in particular the engine handling and some overstresses are not simulated or are without any consequence. In *FlightGear* it is (up to now) not possible to damage a helicopter in flight.

The helicopter flight model of *FlightGear* is quite realistic. The only exceptions are "vortex ring conditions". These occur if you descend too fast and perpendicularly (without forward speed). The heli can get into its own rotor downwash causing the lift to be substantially reduced. Recovering from this condition is possible only at higher altitudes. On the Internet you can find a video of a Seaking helicopter, which got into this condition during a flight demonstration and touched down so hard afterwards that it was completely destroyed.

For all *FlightGear* helicopters the parameters are not completely optimized and thus the performance data between model and original can deviate slightly. On the hardware side I recommend the use of a "good" joystick. A joystick without

springs is recommended because it will not center by itself. You can either re-
move the spring from a normal joystick, or use a force feedback joystick, with a
disconnected voltage supply. Further, the joystick should have a "thrust controller"
(throttle). For controlling the tail rotor you should have pedals or at least a twistable
joystick - using a keyboard is hard. *FlightGear* supports multiple joysticks attached
at the same time.

11.2   Getting started

The number of available helicopters in *FlightGear* is limited. In my opinion the
Bo105 is the easiest to fly, since it reacts substantially more directly than other
helicopters. For flight behavior I can also recommend the S76C. The S76C reacts
more retarded than the Bo.

Once you have loaded *FlightGear*, take a moment to centralize the controls by
moving them around. In particular the collective is often at maximum on startup.

The helicopter is controlled by four functions. The stick (joystick) controls two
of them, the inclination of the rotor disc (and thus the inclination of the helicopter)
to the right/left and forwards/back. Together these functions are called "cyclic
blade control". Next there is the "collective blade control", which is controlled
by the thrust controller. This causes a change of the thrust produced by the rotor.
Since the powering of the main rotor transfers a torque to the fuselage, this must
be compensated by the tail rotor. Since the torque is dependent on the collective
and on the flight condition as well as the wind on the fuselage, the tail rotor is also
controlled by the pilot using the pedals. If you push the right pedal, the helicopter
turns to the right (!). The pedals are not a steering wheel. Using the pedals you can
yaw helicopter around the vertical axis. The number of revolutions of the rotor is
kept constant (if possible) by the aircraft.

11.3 Lift-Off

First reduce the collective to minimum. To increase the rotor thrust, you have to "pull" the collective. Therefore for minimum collective you have to push the control down (that is the full acceleration position (!) of the thrust controller). Equally, "full power" has the thrust controller at idle. Start the engine with **}**. After few seconds the rotor will start to turn and accelerates slowly. Keep the stick and the pedals approximately centered. Wait until the rotor has finished accelerating. For the Bo105 there is an instruments for engine and rotor speed on the left of the upper row.

Once rotor acceleration is complete, pull the collective very slowly. Keep your eye on the horizon. If the heli tilts or turns even slightly, stop increasing the collective and correct the position/movement with stick and pedals. If you are successful, continue pulling the collective (slowly!).

As the helicopter takes off, increase the collective a little bit more and try to keep the helicopter in a leveled position. The main challenge is reacting to the inadvertent rotating motion of the helicopter with the correct control inputs. Only three things can help you: practice, practice and practice. It is quite common for it to take hours of practice to achieve a halfway good looking hovering flight. Note: The stick position in a stable hover is not the center position of the joystick.

11.4 In the air

To avoid the continual frustration of trying to achieve level flight, you may want to try forward flight. After take off continue pulling the collective a short time and then lower the nose a slightly using the control stick. The helicopter will accelerate forward. With forward speed the tail rotor does not have to be controlled as precisely due to the relative wind coming from directly ahead. Altogether the flight behavior in forward flight is quite similar to that of an badly trimmed airplane. The "neutral" position of the stick will depend upon airspeed and collective.

Transitioning from forward flight to hovering is easiest if you reduce speed slowly by raising the nose of the helicopter. At the same time, reduce the collective

to stop the helicopter from climbing. As the helicopter slows, "translation lift" is reduced, and you will have to compensate by pulling the collective. When the speed is nearly zero, lower the nose to the position it was when hovering. Otherwise the helicopter will accelerate backwards!

11.5   Back to Earth I

To land the helicopter transition to a hover as described above while reducing the altitude using the collective. Briefly before hitting the ground reduce the rate of descent slowly. A perfect landing is achieved if you managed to zero the altitude, speed and descent rate at the same time (gently). However, such landing are extremely difficult. Most pilots perform a hover more or less near to the ground and then decent slowly to the ground. Landing with forward velocity is easier, however you must make sure you don't land with any lateral (sideways) component to avoid a rollover.

11.6   Back to Earth II

It is worth mentioning autoration briefly. This is a unpowered flight condition, where the flow of air through the rotors rotates the rotor itelf. At an appropriate altitude select a landing point (at first in the size of a larger airfield) and then switch the engine off by pressing **{**. Reduce collective to minimum, place the tail rotor to approximately 0° incidence (with the Bo push the right pedal about half, with As350 the left). Approach at approximately 80 knots. Don't allow the rotor speed to rise more than a few percent over 100%, otherwise the rotor will be damaged (though this is not currently simulated). As you reach the ground, reduce the airspeed by lifting the nose. The descent rate will drop at the same time, so you do not need to pull the collective. It may be the case that the rotor speed rises beyond the permitted range. Counteract this by raising the collective if required. Just above the ground, reduce the descent rate by pulling the collective. The goal is it to touch down with a very low descent rate and no forward speed. With forward speed it is easier, but there is a danger of a roll over if the skids are not aligned parallel to the flight direction. During the approach it is not necessary to adjust the tail rotor, since without power there is almost no torque. If you feel (after some practice),

that autorotation is too easy, try it with a more realistic payload via the `payload` menu.

Part IV

Appendices

Appendix A

Missed approach: If anything refuses to work

In the following section, we tried to sort some problems according to operating system, but if you encounter a problem, it may be a wise idea to look beyond "your" operating system – just in case. If you are experiencing problems, we would strongly advise you to first check the FAQ maintained by Cameron Moore at

http://wiki.flightgear.org/Frequently_asked_questions.

Moreover, the source code contains a directory `docs-mini` containing numerous ideas on and solutions to special problems. This is also a good place to go for further reading.

A.1 FlightGear Problem Reports

The best place to look for help is generally the mailing lists, specifically the **[Flightgear-User]** mailing list. If you happen to be running a Git version of *FlightGear*, you may want to subscribe to the **[Flightgear-Devel]** list. Instructions for subscription can be found at

http://www.flightgear.org/mail.html.

It's often the case that someone has already dealt with the issue you're dealing with, so it may be worth your time to search the mailing list archives at

http://sourceforge.net/mailarchive/forum.php?forum_name=flightgear-users
http://sourceforge.net/mailarchive/forum.php?forum_name=flightgear-devel.

You should also consider searching the FlightGear forums for help, instructions and archives at

http://www.flightgear.org/forums.

There are numerous developers and users reading those lists and forums, so questions are generally answered. However, messages of the type *FlightGear does*

not compile on my system. What shall I do? are hard to answer without any further detail given, aren't they? Here are some things to consider including in your message when you report a problem:

- **Operating system:** (Linux Fedora 17. . ./Windows Seven 64 bits. . .)

- **Computer:** (Pentium Dual Core, 2,3GHz. . .)

- **Graphics board/chip:** (ATI Radeon HD 770 XT/NVidia GeForce GTX 590. . .)

- **Compiler/version:** (GCC version 4.6.3. . .)

- **Versions of relevant libraries:** (PLIB 1.8.5, OpenSceneGraph 3.0.1. . .)

- **Type of problem:** (Linker dies with message. . .)

- **Steps to recreate the problem:** Start at KSFO, turn off brakes . . .

For getting a trace of the output which *FlightGear* produces, the following command may come in handy (may need to be modified on some OSs or may not work on others at all, though):

```
%FG_ROOT/BIN/fgfs >log.txt 2>&1
```

One final remark: Please avoid posting binaries to these lists or forums! List subscribers are widely distributed, and some users have low bandwidth and/or metered connections. Large messages may be rejected by the mailing list administrator. Thanks.

A.2   General problems

- *FlightGear* runs SOOO slow.
  If *FlightGear* says it's running with something like 1 fps (frame per second) or below you typically don't have working hardware OpenGL support. There may be several reasons for this. First, there may be no OpenGL hardware drivers available for older cards. In this case it is highly recommended to get a new board.

  Second, check if your drivers are properly installed. Several cards need additional OpenGL support drivers besides the "native" windows ones.

- Either `configure` or `make` dies with not found *PLIB* headers or libraries. Make sure you have the latest version of *PLIB* (> version 1.8.4) compiled and installed. Its headers like `pu.h` have to be under `/usr/include/plib` and its libraries, like `libplibpu.a` should be under `/lib`. Double check there are no stray *PLIB* headers/libraries sitting elsewhere!

  Besides, check carefully the error messages of `configure`. In several cases, it says what is missing.

A.3   Potential problems under Linux

Since we don't have access to all possible flavors of Linux distributions, here are some thoughts on possible causes of problems. (This Section includes contributions by Kai Troester.)

- Wrong library versions
  This is a rather common cause of grief especially when you prefer to install the libraries needed by *FlightGear* by hand. Be sure that especially the Mesa library contains support for the 3DFX board and that GLIDE libraries are installed and can be found. If a `ldd ẁhich fgfs`` complains about missing libraries you are in trouble.

  You should also be sure to *always* keep the *latest* version of *PLIB* on your system. Lots of people have failed miserably to compile *FlightGear* just because of an outdated plib.

- Missing permissions
  In case you are using XFree86 before release 4.0 the *FlightGear* binary may need to be setuid root in order to be capable of accessing some accelerator boards (or a special kernel module as described earlier in this document) based on 3DFX chips. So you can either issue a

  ```
  chown root.root /usr/local/bin/fgfs ;
  chmod 4755 /usr/local/bin/fgfs
  ```

  to give the *FlightGear* binary the proper rights or install the 3DFX module. The latter is the "clean" solution and strongly recommended!

- Non-default install options
  FlightGear will display a lot of diagnostics while starting up. If it complains about bad looking or missing files, check that you installed them in the way they are supposed to be installed (i.ẻwith the latest version and in the proper location). The canonical location *FlightGear* wants its data files under `/usr/local/lib`. Be sure to grab the latest versions of everything that might be needed!

- Compile problems in general
  Make sure you have the latest (official) version of gcc. Old versions of gcc are a frequent source of trouble! On the other hand, some versions of the RedHat 7.0 reportedly have certain problems compiling *FlightGear* as they include a preliminary version of gcc.

A.4   Potential problems under Windows

- The executable refuses to run.
  You may have tried to start the executable directly either by double-clicking

fgfs.exe in Windows Explorer or by invoking it within a MS-DOS shell. Double-clicking via Explorer never works (unless you set the environment variable FG_ROOT in autoexec.bat or otherwise). Rather double-click fgrun. For more details, check Chapter 4.

Another cause of grief might be that you did not download the most recent versions of the base package files required by *FlightGear*, or you did not download any of them at all. Have a close look at this, as the scenery/texture format is still under development and may change frequently. For more details, check Chapter 3.

Next, if you run into trouble at runtime, do not use Windows utilities for unpacking the .tar.gz. If you did, try it in the Cygnus shell with tar xvfz instead.

- L'exécutable refuse de se lancer.
  Vous pouvez avoir essayé de lancer l'exécutable directement en double-cliquant sur fgfs.exe dans l'explorateur Windows ou en l'invoquant au travers d'une invite de commandes MS-DOS. Double-cliquer via l'explorateur de fonctionne jamais (sauf si vous avez défini la variable d'environnement FG_ROOT dans l'autoexec.bat ou d'une autre manière). Préférez le double-clic sur fgrun. Pour plus de détails, consultez le chapitre 4.

  Une autre cause de grief peut s'expliquer par le fait que vous n'avez pas téléchargé les versions les plus récentes du paquetage de base nécessaires à *FlightGear*, ou que vous ne les avez pas téléchargé du tout. Jetez souvent un œil à ceux-ci, car le format des scènes et des textures fait toujours l'objet d'un développement intensif. Pour plus de détails, reportez-vous au chapitre 3.

  Ensuite, si vous rencontrez un problème au démarrage, n'utilisez pas les utilitaires Windows pour décompresser les fichiers .tar.gz. Si vous l'avez fait, essayez de le faire dans l'invite de commandes Cygnus en préférant un tar xvfz à la place.

- *FlightGear* ignores the command line parameters.
  There can be a problem with passing command line options containing a "=" on the command line. Instead create a batch job to include your options and run that instead.

- I am unable to build *FlightGear* under MSVC/MS DevStudio.
  By default, *FlightGear* is build with GNU GCC. The Win32 port of GNU GCC is known as Cygwin. For hints on *Makefiles* required for MSVC or MSC DevStudio have a look into

  https://www.gitorious.org/fg/flightgear/trees/next.

  In principle, it should be possible to compile *FlightGear* with the project files provided with the source code.

- Compilation of *FlightGear* dies.
  There may be several reasons for this, including true bugs. However, before trying to do anything else or report a problem, make sure you have the latest version of the *Cygwin* compiler. In case of doubt, start `setup.exe` anew and download and install the most recent versions of bundles as they possibly may have changed.

Appendix B

Landing: Some further thoughts before leaving the plane

B.1 A Sketch on the History of *FlightGear*

History may be a boring subject. However, from time to time there are people asking for the history of *FlightGear*. As a result, we'll give a short outline.

The *FlightGear* project goes back to a discussion among a group of net citizens in 1996 resulting in a proposal written by David Murr who, unfortunately, dropped out of the project (as well as the net) later. The original proposal is still available from the *FlightGear* web site and can be found under

http://www.flightgear.org/proposal-3.0.1.

 Although the names of the people and several of the details have changed over time, the spirit of that proposal has clearly been retained up to the present time.

Actual coding started in the summer of 1996 and by the end of that year essential graphics routines were completed. At that time, programming was mainly performed and coordinated by Eric Korpela from Berkeley University. Early code ran under Linux as well as under DOS, OS/2, Windows 95/NT, and Sun-OS. This was found to be quite an ambitious project as it involved, among other things, writing all the graphics routines in a system-independent way entirely from scratch.

Development slowed and finally stopped in the beginning of 1997 when Eric was completing his thesis. At this point, the project seemed to be dead and traffic on the mailing list went down to nearly nothing.

It was Curt Olson from the University of Minnesota who re-launched the project in the middle of 1997. His idea was as simple as it was powerful: Why invent the wheel a second time? There have been several free flight simulators available running on workstations under different flavors of UNIX. One of these, LaRCsim (developed by Bruce Jackson from NASA), seemed to be well suited to the approach. Curt took this one apart and re-wrote several of the routines such as to make them build as well as run on the intended target platforms. The key idea in doing so was

to exploit a system-independent graphics platform: OpenGL.

In addition, a clever decision on the selection of the basic scenery data was made in the very first version. *FlightGear* scenery is created based on satellite data published by the U. S. Geological Survey. These terrain data are available from

http://edc.usgs.gov/geodata/

for the U.S., and

http://edcdaac.usgs.gov/gtopo30/gtopo30.html,

resp., for other countries. Those freely accessible scenery data, in conjunction with scenery building tools included with *FlightGear*, are an important feature enabling anyone to create his or her own scenery.

This new *FlightGear* code - still largely being based on the original LaRCsim code - was released in July 1997. From that moment the project gained momentum again. Here are some milestones in the more recent development history.

B.1.1   Scenery

- Texture support was added by Curt Olson in spring 1998. This marked a significant improvement in terms of reality. Some high-quality textures were submitted by Eric Mitchell for the *FlightGear* project. Another set of high-quality textures was added by Erik Hofman ever since.

- After improving the scenery and texture support frame rate dropped down to a point where *FlightGear* became unflyable in spring 1998. This issue was resolved by exploiting hardware OpenGL support, which became available at that time, and implementing view frustrum culling (a rendering technique that ignores the part of the scenery not visible in a scene), done by Curt Olson. With respect to frame rate one should keep in mind that the code, at present, is in no way optimized, which leaves room for further improvements.

- In September 1998 Curt Olson succeeded in creating a complete terrain model for the U.S. The scenery is available worldwide now, via a clickable map at:

  http://www.flightgear.org/download/scenery/.

- Scenery was further improved by adding geographic features including lakes, rivers, and coastlines later. Textured runways were added by Dave Cornish in spring 2001. Light textures add to the visual impression at night. To cope with the constant growth of scenery data, a binary scenery format was introduced in spring 2001. Runway lighting was introduced by Curt Olson in spring 2001. Finally, a completely new set of scenery files for the whole world was created by William Riley based on preparatory documentation by

David Megginson in summer 2002. This is based on a data set called VMap0 as an alternative to the GSHHS data used so far. This scenery is a big improvement as it has world wide coverage of main streets, rivers, etc., while it's downside are much less accurate coast lines. *FlightGear*'s base scenery is based on these new scenery files since summer 2002.

- There was support added for static objects to the scenery in 2001, which permits placing buildings, static planes, trees and so on in the scenery.

- The world is populated with random ground objects with appropriate type and density for the local ground cover type since summer 2002. This marks a major improvement of reality and is mainly thanks to work by D. Megginson.

- Today, the effort is still going on, with the use of Terrasync, the tool for on-the-fly scenery download, the powerful mapserver and scenemodels infrastructure laying behind, as well as webforms enabling to quickly add or update objects. Scenery generation tools have been updated in order to use more accurate data such as the 8.50 apt.dat format, as well as external data such as OpenStreetMap, when the licence is adequate.

B.1.2 Aircraft

- A HUD (head up display) was added based on code provided by Michele America and Charlie Hotchkiss in the fall of 1997 and was improved later by Norman Vine. While not generally available for real Cessna 172, the HUD conveniently reports the actual flight performance of the simulation and may be of further use in military jets later.

- A rudimentary autopilot implementing heading hold was contributed by Jeff Goeke-Smith in April 1998. It was improved by the addition of an altitude hold and a terrain following switch in October 1998 and further developed by Norman Vine later.

- Friedemann Reinhard developed early instrument panel code, which was added in June 1998. Unfortunately, development of that panel slowed down later. Finally, David Megginson decided to rebuild the panel code from scratch in January 2000. This led to a rapid addition of new instruments and features to the panel, resulting in nearly all main instruments being included until spring 2001. A handy minipanel was added in summer 2001.

- Finally, LaRCsims Navion was replaced as the default aircraft when the Cessna 172 was stable enough in February 2000 - a move most users will welcome. There are now several flight model and airplane options to choose from at runtime. Jon Berndt has invested a lot of time in a more realistic and versatile flight model with a more powerful aircraft configuration method. *JSBSim*, as it has come to be called, did replace LaRCsim as the default

flight dynamics model (FDM), and it is planned to include such features as fuel slosh effects, turbulence, complete flight control systems, and other features not often found all together in a flight simulator. As an alternative, Andy Ross added another flight dynamics model called *YASim* (Yet Another Flight Dynamics Simulator) which aims at simplicity of use and is based on fluid dynamics, by the end of 2001. This one bought us flight models for a 747, an A4, and a DC-3. Alternatively, a group around Michael Selig from the UIUC group provided another flight model along with several planes since around 2000.

- A fully operational radio stack and working radios were added to the panel by Curt Olson in spring 2000. A huge database of Navaids contributed by Robin Peel allows IFR navigation since then. There was basic ATC support added in fall 2001 by David Luff. This is not yet fully implemented, but displaying ATIS messages is already possible. A magneto switch with proper functions was added at the end of 2001 by John Check and David Megginson. Moreover, several panels were continually improved during 2001 and 2002 by John and others. *FlightGear* now allows flying ILS approaches and features a Bendix transponder.

- In 2002 functional multi-engine support found its way into *FlightGear*. *JSBSim* is now the default FDM in *FlightGear*.

- Support of ''true'' 3D panels became stable via contributions from John Check and others in spring 2002. In addition, we got movable control surfaces like propellers etc., thanks to David Megginson.

B.1.3   Environment

- The display of sun, moon and stars have been a weak point for PC flight simulators for a long time. It is one of the great achievements of *FlightGear* to include accurate modeling and display of sun, moon, and planets very early. The corresponding astronomy code was implemented in fall 1997 by Durk Talsma.

- Christian Mayer, together with Durk Talsma, contributed weather code in the winter of 1999. This included clouds, winds, and even thunderstorms.

B.1.4   User Interface

- The foundation for a menu system was laid based on another library, the Portable Library *PLIB*, in June 1998. After having been idle for a time, the first working menu entries came to life in spring 1999.

  PLIB underwent rapid development later. It has been distributed as a separate package by Steve Baker with a much broader range of applications in mind,

since spring 1999. It has provided the basic graphics rendering engine for *FlightGear* since fall 1999.

- In 1998 there was basic audio support, i. e. an audio library and some basic background engine sound. This was later integrated into the abovementioned portable library, *PLIB*. This same library was extended to support joystick/yoke/rudder in October 1999, again marking a huge step in terms of realism. To adapt on different joystick, configuration options were introduced in fall 2000. Joystick support was further improved by adding a self detection feature based on xml joystick files, by David Megginson in summer 2002.

- Networking/multiplayer code has been integrated by Oliver Delise and Curt Olson starting fall 1999. This effort is aimed at enabling *FlightGear* to run concurrently on several machines over a network, either an Intranet or the Internet, coupling it to a flight planner running on a second machine, and more. There emerged several approaches for remotely controlling *FlightGear* over a Network during 2001. Notably there was added support for the "Atlas" moving map program. Besides, an embedded HTTP server developed by Curt Olson late in 2001 can now act a property manager for external programs.

- Manually changing views in a flight simulator is in a sense always "unreal" but nonetheless required in certain situations. A possible solution was supplied by Norman Vine in the winter of 1999 by implementing code for changing views using the mouse. Alternatively, you can use a hat switch for this purpose, today.

- A property manager was implemented by David Megginson in fall 2000. It allows parsing a file called `.fgfsrc` under UNIX/Linux and `system.fgfsrc` under Windows for input options. This plain ASCII file has proven useful in submitting the growing number of input options, and notably the joystick settings. This has shown to be a useful concept, and joystick, keyboard, and panel settings are no longer hard coded but set using *.xml files since spring 2001 thanks to work mainly by David Megginson and John Check.

During development there were several code reorganization efforts. Various code subsystems were moved into packages. As a result, code is organized as follows at present:

The base of the graphics engine is **OpenGL**, a platform independent graphics library. Based on OpenGL, the Portable Library *PLIB* provides basic rendering, audio, joystick etc. routines. Based on *PLIB* is *SimGear*, which includes all of the basic routines required for the flight simulator as well as for building scenery. On top of *SimGear* there are (i) *FlightGear* (the simulator itself), and (ii) *TerraGear*, which comprises the scenery building tools.

This is by no means an exhaustive history and most likely some people who have made important contributions have been left out. Besides the above-named contributions there was a lot of work done concerning the internal structure by: Jon S. Berndt, Oliver Delise, Christian Mayer, Curt Olson, Tony Peden, Gary R. Van Sickle, Norman Vine, and others. A more comprehensive list of contributors can be found in Chapter B as well as in the `Thanks` file provided with the code. Also, the *FlightGear* Website contains a detailed history worth reading of all of the notable development milestones at

> http://www.flightgear.org/version.html

B.2 Those, who did the work

Did you enjoy the flight? In case you did, don't forget those who devoted hundreds of hours to that project. All of this work is done on a voluntary basis within spare time, thus bare with the programmers in case something does not work the way you want it to. Instead, sit down and write them a kind (!) mail proposing what to change. Alternatively, you can subscribe to the *FlightGear* mailing lists and contribute your thoughts there. Instructions to do so can be found at

> http://www.flightgear.org/mail.html.

Essentially there are two lists, one of which being mainly for the developers and the other one for end users. Besides, there is a very low-traffic list for announcements.

The following names the people who did the job (this information was essentially taken from the file `Thanks` accompanying the code).

A1 Free Sounds
Granted permission for the *FlightGear* project to use some of the sound effects from their site. Homepage under

> http://www.a1freesoundeffects.com/

Syd Adams
Added clipping for 2D instruments, ATC volume control and created a wide variety of aircraft.

Raul Alonzo
Mr. Alonzo is the author of Ssystem and provided his kind permission for using the moon texture. Parts of his code were used as a template when adding the texture. Ssystem Homepage can be found at:

> http://www1.las.es/~amil/ssystem/.

Michele America
Contributed to the HUD code.

Michael Basler

Author of Installation and Getting Started. Flight Simulation Page at

> http://www.geocities.com/pmb.geo/flusi.htm

Jon S. Berndt

Working on a complete C++ rewrite/reimplimentation of the core FDM. Initially he is using X15 data to test his code, but once things are all in place we should be able to simulate arbitrary aircraft. Jon maintains a page dealing with Flight Dynamics at:

> http://jsbsim.sourceforge.net/

Special attention to X15 is paid in separate pages on this site. Besides, Jon contributed via a lot of suggestions/corrections to this Guide.

Paul Bleisch

Redid the debug system so that it would be much more flexible, so it could be easily disabled for production system, and so that messages for certain subsystems could be selectively enabled. Also contributed a first stab at a config file/command line parsing system.

Jim Brennan

Provided a big chunk of online space to store USA scenery for *FlightGear*!.

Bernie Bright

Many C++ style, usage, and implementation improvements, STL portability and much, much more. Added threading support and a threaded tile pager.

Stuart Buchanan

Updated various parts of the manual, wrote the initial tutorial subsystem, developed random vegetation and buildings.

Bernhard H. Buckel

Contributed the README.Linux. Contributed several sections to earlier versions of Installation and Getting Started.

Gene Buckle

A lot of work getting *FlightGear* to compile with the MSVC++ compiler. Numerous hints on detailed improvements.

Ralph Carmichael

Support of the project. The Public Domain Aeronautical Software web site at

> http://www.pdas.com/

has the PDAS CD-ROM for sale containing great programs for astronautical engineers.

Didier Chauveau

Provided some initial code to parse the 30 arcsec DEM files found at:

> http://edcwww.cr.usgs.gov/landdaac/gtopo30/gtopo30.html.

John Check

John maintains the base package CVS repository. He contributed cloud textures, wrote an excellent Joystick Howto as well as a panel Howto. Moreover, he contributed new instrument panel configurations. *FlightGear* page at

http://www.rockfish.net/fg/.

Dave Cornish

Dave created new cool runway textures plus some of our cloud textures.

Oliver Delise

Started a FAQ, Documentation, Public relations. Working on adding some networking/multi-user code. Founder of the FlightGear MultiPilot

Jean-Francois Doue

Vector 2D, 3D, 4D and Matrix 3D and 4D inlined C++ classes. (Based on Graphics Gems IV, Ed. Paul S. Heckbert)

http://www.animats.com/simpleppp/ftp/public_html/topics/developers.html.

Dave Eberly

Contributed some sphere interpolation code used by Christian Mayer's weather data base system.

Francine Evans

Wrote the GPL'd tri-striper we use.

http://www.cs.sunysb.edu/˜stripe/

Oscar Everitt

Created single engine piston engine sounds as part of an F4U package for FS98. They are pretty cool and Oscar was happy to contribute them to our little project.

Bruce Finney

Contributed patches for MSVC5 compatibility.

Olaf Flebbe

Improved the build system for Windows and provided pre-built dependencies.

Melchior Franz

Contributed joystick hat support, a LED font, improvements of the telnet and the http interface. Notable effort in hunting memory leaks in *FlightGear*, *SimGear*, and *JSBSim*.

Jean-loup Gailly and **Mark Adler**

Authors of the zlib library. Used for on-the-fly compression and decompression routines,

http://www.gzip.org/zlib/.

Mohit Garg

Contributed to the manual.

Thomas Gellekum
Changes and updates for compiling on FreeBSD.

Neetha Girish
Contributed the changes for the xml configurable HUD.

Jeff Goeke-Smith
Contributed our first autopilot (Heading Hold). Better autoconf check for external timezone/daylight variables.

Michael I. Gold
Patiently answered questions on OpenGL.

Habibe
Made RedHat package building changes for SimGear.

Mike Hill
For allowing us to concert and use his wonderful planes, available form

http://www.flightsimnetwork.com/mikehill/home.htm,
for *FlightGear*.

Erik Hofman
Major overhaul and parameterization of the sound module to allow aircraft-specific sound configuration at runtime. Contributed SGI IRIX support (including binaries) and some really great textures.

Charlie Hotchkiss
Worked on improving and enhancing the HUD code. Lots of code style tips and code tweaks.

Bruce Jackson (NASA)
Developed the LaRCsim code under funding by NASA which we use to provide the flight model. Bruce has patiently answered many, many questions.

Maik Justus
Added helicopter support, gear/ground interaction and aerotow/winch support to the YASim FDM.

Ove Kaaven
Contributed the Debian binary.

Richard Kaszeta
Contributed screen buffer to ppm screen shot routine. Also helped in the early development of the "altitude hold autopilot module" by teaching Curt Olson the basics of Control Theory and helping him code and debug early versions. Curt's ḂossḂob Hain also contributed to that. Further details available at:

http://www.menet.umn.edu/~curt/fgfs/Docs/Autopilot/AltitudeHold/AltitudeHold.html.

Rich's Homepage is at

http://www.kaszeta.org/rich/.

Tom Knienieder
Ported the audio library first to OpenBSD and IRIX and after that to Win32.

Reto Koradi
Helped with setting up fog effects.

Bob Kuehne
Redid the Makefile system so it is simpler and more robust.

Kyler B Laird
Contributed corrections to the manual.

David Luff
Contributed heavily to the IO360 piston engine model.

Sam van der Mac
Contributed to The Manual by translating HTML tutorials to Latex.

Christian Mayer
Working on multi-lingual conversion tools for fgfs as a demonstration of technology. Contributed code to read Microsoft Flight Simulator scenery textures. Christian is working on a completely new weather subsystem. Donated a hot air balloon to the project.

David Megginson
Contributed patches to allow mouse input to control view direction yoke. Contributed financially towards hard drive space for use by the flight gear project. Updates to README.running. Working on getting fgfs and ssg to work without textures. Also added the new 2-D panel and the save/load support. Further, he developed new panel code, playing better with OpenGL, with new features. Developed the property manager and contributed to joystick support. Random ground cover objects

Cameron Moore
FAQ maintainer. Reigning list administrator. Provided man pages.

Eric Mitchell
Contributed some topnotch scenery textures being all original creations by him.

Anders Morken
Former maintainer of European web pages.

Alan Murta
Created the Generic Polygon Clipping library.

http://www.cs.man.ac.uk/aig/staff/alan/software/

Phil Nelson
Author of GNU dbm, a set of database routines that use extendible hashing and work similar to the standard UNIX dbm routines.

Alexei Novikov
Created European Scenery. Contributed a script to turn fgfs scenery into beautifully rendered 2-D maps. Wrote a first draft of a Scenery Creation Howto.

Curt Olson
Primary organization of the project.
First implementation and modifications based on LaRCsim.
Besides putting together all the pieces provided by others mainly concentrating on the scenery subsystem as well as the graphics stuff. Homepage at
http://www.menet.umn.edu/˜curt/

Brian Paul
We made use of his TR library and of course of Mesa:
http://www.mesa3d.org/brianp/TR.html, http://www.mesa3d.org

Tony Peden
Contributions on flight model development, including a LaRCsim based Cessna 172. Contributed to *JSBSim* the initial conditions code, a more complete standard atmosphere model, and other bugfixes/additions.

Robin Peel
Maintains worldwide airport and runway database for *FlightGear* as well as X-Plane.

Alex Perry
Contributed code to more accurately model VSI, DG, Altitude. Suggestions for improvements of the layout of the simulator on the mailing list and help on documentation.

Friedemann Reinhard
Development of an early textured instrument panel.

Petter Reinholdtsen
Incorporated the GNU automake/autoconf system (with libtool). This should streamline and standardize the build process for all UNIX-like platforms. It should have little effect on IDE type environments since they don't use the UNIX make system.

William Riley
Contributed code to add "brakes". Also wrote a patch to support a first joystick with more than 2 axis. Did the job to create scenery based on VMap0 data.

Andy Ross
Contributed a new configurable FDM called *YASim* (Yet Another Flight Dynamics Simulator, based on geometry information rather than aerodynamic coefficients.

Paul Schlyter
Provided Durk Talsma with all the information he needed to write the astro code. Mr. Schlyter is also willing to answer astro-related questions whenever one needs to.

http://www.welcome.to/pausch/

Chris Schoeneman
Contributed ideas on audio support.

Phil Schubert
Contributed various textures and engine modeling.

http://www.zedley.com/Philip/.

Jonathan R. Shewchuk
Author of the Triangle program. Triangle is used to calculate the Delauney triangulation of our irregular terrain.

Gordan Sikic
Contributed a Cherokee flight model for LaRCsim. Currently is not working and needs to be debugged. Use configure `--with-flight-model=cherokee` to build the cherokee instead of the Cessna.

Michael Smith
Contributed cockpit graphics, 3D models, logos, and other images. Project Bonanza

Martin Spott
Co-Author of The Manual.

Jon Stockill
Maintains a database of objects and their location to populate the worldwide scenery.

Durk Talsma
Accurate Sun, Moon, and Planets. Sun changes color based on position in sky. Moon has correct phase and blends well into the sky. Planets are correctly positioned and have proper magnitude. Help with time functions, GUI, and other things. Contributed 2-D cloud layer. Website at

http://people.a2000.nl/dtals/.

UIUC - Department of Aeronautical and Astronautical Engineering
Contributed modifications to LaRCsim to allow loading of aircraft parameters from a file. These modifications were made as part of an icing research project.

Those did the coding and made it all work:
Jeff Scott
Bipin Sehgal
Michael Selig

Moreover, those helped to support the effort:
Jay Thomas
Eunice Lee
Elizabeth Rendon
Sudhi Uppuluri

U. S. Geological Survey

Provided geographic data used by this project.

http://edc.usgs.gov/geodata/

Mark Vallevand
Contributed some METAR parsing code and some win32 screen printing routines.

Gary R. Van Sickle
Contributed some initial GameGLUT support and other fixes. Has done preliminary work on a binary file format. Check

http://www.woodsoup.org/projs/ORKiD/fgfs.htm.

His Ćygwin Tipsṕage might be helpful for you at

http://www.woodsoup.org/projs/ORKiD/cygwin.htm.

Norman Vine
Provided more numerous URL's to the "FlightGear Community". Many performance optimizations throughout the code. Many contributions and much advice for the scenery generation section. Lots of Windows related contributions. Contributed wgs84 distance and course routines. Contributed a great circle route autopilot mode based on wgs84 routines. Many other GUI, HUD and autopilot contributions. Patch to allow mouse input to control view direction. Ultra hires tiled screen dumps. Contributed the initial ǵoto airportánd ŕesetfunctions and the initial http image server code

Roland Voegtli
Contributed great photorealistic textures. Founder of European Scenery Project for X-Plane:

http://www.g-point.com/xpcity/esp/

Carmelo Volpe
Porting *FlightGear* to the Metro Works development environment (PC/Mac).

Darrell Walisser
Contributed a large number of changes to porting *FlightGear* to the Metro Works development environment (PC/Mac). Finally produced the first Macintosh port. Contributed to the Mac part of Getting Started, too.

Ed Williams
Contributed magnetic variation code (impliments Nima WMM 2000). We've also borrowed from Ed's wonderful aviation formulary at various times as well. Website at http://williams.best.vwh.net/.

Jim Wilson
Wrote a major overhaul of the viewer code to make it more flexible and modular.

Contributed many small fixes and bug reports. Contributed to the PUI property browser and to the autopilot.

Jean-Claude Wippler
Author of MetaKit - a portable, embeddible database with a portable data file format previously used in *FlightGear*. Please see the following URL for more info:

http://www.equi4.com/metakit/

Woodsoup Project

While *FlightGear* no longer uses Woodsoup servies we appreciate the support provided to our project during the time they hosted us. Once they provided computing resources and services so that the *FlightGear* project could have a real home.
http://www.woodsoup.org/

Robert Allan Zeh
Helped tremendously in figuring out the Cygnus Win32 compiler and how to link with dll's. Without him the first run-able Win32 version of *FlightGear* would have been impossible.

Others
The following individuals have contributed to the scenery object database: Jon Stockill, Martin Spott, Dave Martin, Thomas Foerster, Chris Metzler, Frederic Bouvier, Melchior Franz, Roberto Inzerillo, Erik Hofman, Mike Round, Innis Cunningham, David Megginson, Stuart Buchanan, Josh Babcock, Esa Hyytia, Mircea Lutic, Jens Thoms Toerring, Mark Akermann, Torsten Dreyer, Martin C. Doege, Alexis Bory, Sebastian Bechtold, Julien Pierru, Bertrand Augras, Gerard Robin, Jakub Skibinski, Morten Oesterlund Joergensen, Carsten Vogel, Dominique Lemesre, Daniel Leygnat, Bertrand Gilot, Morten Skyt Eriksen, Alex Bamesreiter, Oliver Predelli, Georg Vollnhals, and Paul Richter.

B.3   What remains to be done

If you read (and, maybe, followed) this guide up to this point you may probably agree: *FlightGear* even in its present state, is not at all for the birds. It is already a flight simulator which sports even several selectable flight models, several planes with panels and even a HUD, terrain scenery, texturing, all the basic controls and weather.

Despite, *FlightGear* needs – and gets – further development. Except internal tweaks, there are several fields where *FlightGear* needs basics improvement and development. A first direction is adding airports, buildings, and more of those things bringing scenery to real life and belonging to realistic airports and cities. Another task is further implementation of the menu system, which should not be

too hard with the basics being working now. A lot of options at present set via command line or even during compile time should finally make it into menu entries. Finally, *FlightGear* lacks any ATC until now.

There are already people working in all of these directions. If you're a programmer and think you can contribute, you are invited to do so.

Achnowledgements

Obviously this document could not have been written without all those contributors mentioned above making *FlightGear* a reality.

First, I was very glad to see Martin Spott entering the documentation effort. Martin provided not only several updates and contributions (notably in the OpenGL section) on the Linux side of the project but also several general ideas on the documentation in general.

Besides, I would like to say special thanks to Curt Olson, whose numerous scattered Readmes, Thanks, Webpages, and personal eMails were of special help to me and were freely exploited in the making of this booklet.

Next, Bernhard Buckel wrote several sections of early versions of that Guide and contributed at lot of ideas to it.

Jon S. Berndt supported me by critical proofreading of several versions of the document, pointing out inconsistences and suggesting improvements.

Moreover, I gained a lot of help and support from Norman Vine. Maybe, without Norman's answers I would have never been able to tame different versions of the *Cygwin – FlightGear* couple.

We were glad, our Mac expert Darrell Walisser contributed the section on compiling under Mac OS X. In addition he submitted several Mac related hints and fixes.

Further contributions and donations on special points came from John Check, (general layout), Oliver Delise (several suggestions including notes on that chapter), Mohit Garg (OpenGL), Kyler B. Laird (corrections), Alex Perry (OpenGL), Kai Troester (compile problems), Dave Perry (joystick support), and Michael Selig (UIUC models).

Besides those whose names got lost withing the last-minute-trouble we'd like to express our gratitude to the following people for contributing valuable 'bug fixes' to this version of The FlightGear Manual (in random order): Cameron Moore, Melchior Franz, David Megginson, Jon Berndt, Alex Perry,, Dave Perry, Andy Ross, Erik Hofman, and Julian Foad.

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