

FlightGear READMEs

FlightGear Community

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1 Introduction

This document is autogenerated from the various plain text README files found in the Docs/ directory of your FlightGear installation, presented in PDF format for ease of use. These are targetted at those delving into the internals of FG, or developing aircraft.

For help running or using FlightGear, please see Docs/getstart.pdf.

2 3DClouds

Configuring 3D Clouds

=====

3D clouds can be created in two ways:

- By placing individual clouds using a command (e.g. from Nasal)
- Using the global weather function, which reads cloud definition from an XML file.

Placing Clouds Individually

=====

Clouds are created using the "add-cloud" command, passing a property node defining the location and characteristics of the cloud.

Location is defined by the following properties:

<layer> - The cloud layer number to add the cloud to. (default 0)
<index> - A unique identifier for the cloud in the layer. If a cloud already exists with this index, the new cloud will not be created, and 0 is returned.
<lon-deg> - Longitude to place the cloud, in degrees (default 0)
<lat-deg> - Latitude to place the cloud, in degrees (default 0)
<alt-ft> - Altitude to place the cloud, relative to the layer (!) in ft (default 0)
<x-offset-m> - Offset in m from the lon-deg. +ve is south (default 0)
<y-offset-m> - Offset in m from the lat-deg. +ve is east (default 0)

The cloud itself is built up of a number of "sprites" - simple 2D textures that are always rotated to be facing the viewer. These sprites are handled by a OpenGL Shader - a small program that is run on your graphics card.

The cloud is defined by the following properties:

<min-cloud-width-m> - minimum width of the cloud in meters (default 500)
<max-cloud-width-m> - maximum width of the cloud (default min-cloud-width-m*1.5)
<min-cloud-height-m> - minimum height of the cloud (default 400)
<max-cloud-height-m> - maximum height of the cloud (default min-cloud-height-m*1.5)
<texture> - texture file of sprites to use (default cl_cumulus.png)
<num-textures-x> - number of cloud textures defined horizontally in the texture file (default 4)
<num-textures-y> - number of cloud textures defined vertically in the texture file (default 4)
<height-map-texture> - whether to choose the vertical texture index based on sprite height within the clouds (default false)
<num-sprites> - Number of sprite to generate for the cloud (default 20)
<min-sprite-width-m> - minimum width of the sprites used to create the cloud (default 200)
<max-sprite-width-m> - maximum width of the sprites used to create the cloud (default min-sprite-width-m*1.5)
<min-sprite-height-m> - minimum height of the sprites used to create the cloud (default 150)
<max-sprite-height-m> - maximum height of the sprites used to create the cloud (default min-sprite-height-m*1.5)
<z-scale> - vertical scaling factor to apply to the sprite after billboard. A small value would create a sprite that looks squashed when viewed from the side. (default 1.0)
<min-bottom-lighting-factor> - See Shading below (default 1.0)
<max-bottom-lighting-factor> - See Shading below (default min-...-factor + 0.1)
<min-middle-lighting-factor> - See Shading below (default 1.0)
<max-middle-lighting-factor> - See Shading below (default min-...-factor + 0.1)
<min-top-lighting-factor> - See Shading below (default 1.0)

<max-top-lighting-factor> - See Shading below (default min-...-factor + 0.1)
 <min-shade-lighting-factor> - See Shading below (default 0.5)
 <max-shade-lighting-factor> - See Shading below (default min-...-factor + 0.1)

Shading

the [min|max]-...-lighting-factor properties allow you to define diffuse lighting multipliers to the bottom, middle, top, sunny and shaded parts of the cloud. In each case, individual clouds will have a random multiplier between the min and max values used to allow for some variation between individual clouds.

The top, middle and bottom lighting factors are applied based on the pixels vertical position in the cloud. A linear interpolation is used either between top/middle (if the pixel is above the middle of the cloud) or middle/bottom (if the pixel is below the middle of the cloud).

The top factor is also applied to `_all_` pixels on the sunny side of the cloud. The shade factor is applied based on the pixel position away from the sun, linearly interpolated from top to shade. E.g this is not a straight linear interpolation from top to shade across the entire cloud.

The final lighting factor is determined by the minimum of the vertical factor and the sunny/shade factor. Note that this is applied to the individual pixels, not sprites.

Textures

The texture to use for the sprites is defined in the <texture> tag. To allow some variation, you can create a texture file containing multiple sprites in a grid, and define the <num-textures-x/y> tags. The code decides which texture to use for a given sprite : randomly in the x-direction and based on the altitude of the sprite within the cloud in the y-direction if <height-map-texture> is set. Therefore, you should put sprite textures you want to use for the bottom of your cloud at the bottom of the texture file, and those you want to use for the top of the cloud at the top of the texture file.

For example, the following Nasal snippet will create a cloud immediately above the aircraft at an altitude of 1000 ft above `/environment/clouds/layer[0]/elevation-ft` :

```
var p = props.Node.new({ "layer" : 0,
                        "index": 1,
                        "lat-deg": getprop("/position/latitude-deg"),
                        "lon-deg": getprop("/position/longitude-deg"),
                        "alt-ft" : 1000 });
fgcommand("add-cloud", p);
```

Moving Individual Clouds

=====

Clouds may be moved by using the "move-cloud" command. This takes the following property arguments.

<layer> - The cloud layer number containing the cloud to move. (default 0)
 <index> - The unique identifier of the cloud to move.
 <lon-deg> - Longitude to place the cloud, in degrees (default 0)
 <lat-deg> - Latitude to place the cloud, in degrees (default 0)
 <alt-ft> - Altitude to place the cloud, relative to the layer (!) in ft (default 0)
 <x-offset-m> - Offset in m from the lon-deg. +ve is south (default 0)
 <y-offset-m> - Offset in m from the lat-deg. +ve is east (default 0)

Deleting Individual Clouds

=====

Clouds may be deleted by using the "del-cloud" command. This takes the following property arguments.

<layer> - The cloud layer number containing the cloud to delete. (default 0)
<index> - The unique identifier of the cloud to delete.

Global 3D Clouds

=====

The global weather system uses sets of clouds defined in
FG_ROOT/Environment/cloudlayers.xml

The file has 3 distinct sections: layers, cloud boxes and clouds,
described below.

Notes for those editing clouds:

- All distances are in m. Note that this is in contrast to cloud heights in METAR etc. which are in ft.
- The XML file is loaded into the properties system, so you can modify the settings in-sim, and see the results by re-generating the cloud layer. The simplest way to do this is to disable METAR, and control the cloud layers using the Clouds dialog, and in particular the coverage.
- Texture files are in .png format, and have a transparent background. To make the textures easier to edit, create a black layer behind them, so there is some contrast between the background and the white cloud. Having a grid based on the texture dimensions also helps, so you don't bleed over the edges, which causes ugly sharp horizontal and vertical lines.

Clouds

=====

The cloud definitions are as described above for placing individual clouds, but no position information is used (this is defined in the cloud box and layers below).

Cloud Boxes

=====

The <boxes> section contains definitions of groups of clouds, for example an entire towering CB mass.

The <boxes> section contains a number of named types, which are referenced by the <layers> section, described below. Therefore, the names used are completely user-defined.

Each of the named section consists of one or more <box> section, defining a particular cloud type

Each <box> section contains the following tags:

<type> - The cloud to use, defined above
<count> - The number of clouds to generate (+/- 50%)
<width> - The x and y within which these clouds should be generated
<height> - The height within which the clouds should be generated
<hdist> - The horizontal distribution of the clouds within the area.
 Equates to a sum of random distributions. Defaults to 1.
 1 = even distribution, 2 = distributed towards the center.
 3 = very strongly distributed towards the center.

<vdist> - The vertical distribution of the clouds. As for hdist.

If the /sim/rendering/clouds3d-density is less than 1.0 (100%), then a proportional number of clouds will be displayed.

The following example shows a stratus cloud group, which consists of 5 st-large clouds and 5 st-small clouds, distributed in a box 2000mx2000m, and 100m high, evenly distributed.

```
<st>
  <box>
    <type>st-large</type>
    <count>5</count>
    <width>2000</width>
    <height>100</height>
  </box>
  <box>
    <type>st-small</type>
    <count>5</count>
    <width>2000</width>
    <height>100</height>
  </box>
</st>
```

Layers
=====

The <layers> section contains definitions for a specific layer type. The layer type is derived from the METAR/Weather settings by FG itself.

Each layer type is a named XML tag, i.e.: ns, sc, st, ac, cb, cu. If a layer type is not defined, then a 2D layer is used instead.

The layer type contains one or more <cloud> definitions. This defines a type of cloud box, and a weighting for that type (<count>).

For example, the following XML fragment will produce 3 "cb" cloud boxes for every 1 "cu":

```
<cloud>
  <name>cb</name>
  <count>3</count>
</cloud>
<cloud>
  <name>cu</name>
  <count>1</count>
</cloud>
```

Clouds are randomly distributed across the sky in the x/y plane, but the height of them is set by the weather conditions, with a random height range applied, defined by <grid-z-rand>

3 Add-ons

`-- coding: utf-8; fill-column: 72; --`

Add-ons in FlightGear
=====

This document explains how add-ons work in FlightGear. The add-on feature was first added in FlightGear 2017.3. This document describes an evolution of the framework that appeared in FlightGear 2017.4.

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Introduction

`fgfs` can be passed the `--addon=<path>` option, where `<path>` indicates an add-on directory. Such a directory, when used as the argument of `--addon`, receives special treatment :

- 1) The add-on directory is added to the list of aircraft paths.
- 2) The add-on directory must contain a `PropertyList` file called `addon-metadata.xml` that gives the name of the add-on, its identifier (id), its version and possibly a few other things (see details below).
- 3) The add-on directory may contain a `PropertyList` file called `addon-config.xml`, in which case it will be loaded into the Property Tree at FlightGear startup, as if it were passed to the `--config fgfs` option.
- 4) The add-on directory must contain a Nasal file called `addon-main.nas`. This file will be loaded at startup too, and its

main() function run in the namespace `__addon[ADDON_ID]__`, where `ADDON_ID` is the add-on identifier specified in the `addon-metadata.xml` file. The `main()` function is passed one argument: the `addons.Addon` object (a Nasal ghost, see below) corresponding to the add-on being loaded. This operation is done by `$FG_ROOT/Nasal/addons.nas` at the time of this writing.

Also, the Property Tree is populated (under `/addons`) with information about registered add-ons. More details will be given below.

The `--addon` option can be specified zero or more times; each of the operations indicated above is carried out for every specified add-on in the order given by the `--addon` options used: that's what we call add-on registration order, or add-on load order. In other words, add-ons are registered and loaded in the order specified by the `--addon` options used.

1. Terminology

~~~~~

### add-on base path

Path to a directory containing all of the add-on files. This is the path passed to the `--addon fgfs` option, when one wants to load the add-on in question.

### add-on identifier (id)

A string such as `org.flightgear.addons.ATCChatter` or `user.joe.MyGreatAddon`, used to uniquely identify an add-on. The add-on identifier is declared in `<path>/addon-metadata.xml`, where `<path>` is the add-on base path.

### add-on registration

When a `--addon` option is processed, FlightGear ensures that the add-on identifier found in the corresponding `addon-metadata.xml` file isn't already used by an add-on from a previous `--addon` option on the same command line, and stores the add-on metadata inside dedicated C++ objects. This process is called add-on registration.

### add-on loading

The following sequence of actions:

- a) loading an add-on's `addon-main.nas` file in the namespace `__addon[ADDON_ID]__`
- b) calling its `main()` function

is performed later (see `$FG_ROOT/Nasal/addons.nas`) and called add-on loading.

## 2. The `addon-metadata.xml` file

~~~~~

Every add-on must have in its base directory a file called '`addon-metadata.xml`'. This section explains how to write this file.

Sample `addon-metadata.xml` file

=====

Here is an example of an addon-metadata.xml file, for a hypothetical add-on called "Flying Turtle" distributed by Joe User:

```
<?xml version="1.0" encoding="UTF-8"?>

<PropertyList>
  <meta>
    <file-type type="string">FlightGear add-on metadata</file-type>
    <format-version type="int">1</format-version>
  </meta>

  <addon>
    <identifier type="string">user.joe.FlyingTurtle</identifier>
    <name type="string">Flying Turtle</name>
    <version type="string">1.0.0rc2</version>

    <authors>
      <author>
        <name type="string">Joe User</name>
        <email type="string">optional_address@example.com</email>
        <url type="string">http://joe.example.com/foobar</url>
      </author>

      <author>
        <name type="string">Jane Maintainer</name>
        <email type="string">jane@example.com</email>
        <url type="string">https://jane.example.com/</url>
      </author>
    </authors>

    <maintainers>
      <maintainer>
        <name type="string">Jane Maintainer</name>
        <email type="string">jane@example.com</email>
        <url type="string">https://jane.example.com/</url>
      </maintainer>
    </maintainers>

    <short-description type="string">
      Allow flying with new foobar powers.
    </short-description>

    <long-description type="string">
      This add-on enables something really great involving turtles...
    </long-description>

    <localized>
      <fr>
        <short-description type="string">
          Permet de voler avec de nouveaux pouvoirs foobar.
        </short-description>
        <name>
          Tortue volante
        </name>
      </fr>
      <de>
        <short-description type="string">
          Erlaube das Fliegen mit neuen Foobar-KrÄften.
        </short-description>
      </de>
    </localized>

    <license>
```

```

    <designation type="string">
      GNU GPL version 2 or later
    </designation>

    <file type="string">
      COPYING
    </file>

    <url type="string">
      https://www.gnu.org/licenses/old-licenses/gpl-2.0.en.html
    </url>
  </license>

  <min-FG-version type="string">2017.4.0</min-FG-version>
  <max-FG-version type="string">none</max-FG-version>

  <urls>
    <home-page type="string">
      https://example.com/quux
    </home-page>

    <download type="string">
      https://example.com/quux/download
    </download>

    <support type="string">
      https://example.com/quux/support
    </support>

    <code-repository type="string">
      https://example.com/quux/code-repository
    </code-repository>
  </urls>

  <tags>
    <tag type="string">first tag</tag>
    <tag type="string">second tag</tag>
    <tag type="string">etc.</tag>
  </tags>
</addon>
</PropertyList>

```

General rules =====

We use the terms `field` or `node` interchangeably here to refer to nodes of the `addon-metadata.xml` `PropertyList` file (technically, a field always has a value, possibly empty, therefore fields are all leaf nodes).

Leading and trailing whitespace in each field of `addon-metadata.xml` is removed. All other whitespace is *a priori* preserved (this could depend on the particular field, though).

Most fields are optional. In most cases, omitting a field is the same as leaving it empty. But don't write empty tag fields, it is really too ugly. ;-)

Name and id =====

Nodes: `/addon/name` and `/addon/identifier`

The add-on name is the pretty form. It should not be overly long, but otherwise isn't constrained. On the other hand, the add-on identifier (id), which serves to uniquely identify an add-on:

- must contain only ASCII letters (A-Z, a-z) and dots ('.');
- must be in reverse DNS style (even if the domain doesn't exist), e.g., org.flightgear.addons.ATCChatter for an add-on distributed in FGAddon, or user.joe.FlyingTurtle for Joe User's "Flying Turtle" add-on. Of course, if Joe User owns a domain name and uses it to distribute his add-on, he should put it here.

Authors and maintainers =====

Nodes: /addon/authors and /addon/maintainers

Authors are people who contributed significantly to the add-on.
Maintainers are people currently in charge of maintaining it.

It is possible to declare any number of authors and any number of maintainers---the example above shows only one maintainer for shortness, but this is not a restriction.

For each author and maintainer, you can give a name, an email address and a URL. The name must be non-empty, but the email address and URL need not be specified or may be left empty, which is equivalent. Obviously, if no email address nor URL is given for any maintainer, it is highly desirable that /addon/urls/support contains a usable URL for contacting the add-on maintainers.

The data in children nodes of /addon/maintainers may refer either to real persons or to more abstract entities such as mailing-lists. In case of a real person, the corresponding URL, if specified, is expected to be the person's home page. On the other hand, if a declared "maintainer" is a mailing-list, a good use for the 'url' field is to indicate the address of a web page from which people can subscribe to the mailing-list.

Short and long descriptions =====

Nodes: /addon/short-description and /addon/long-description

The short description should fit on one line (try not to exceed, say, 78 characters), and in general consist of only one sentence.

The long description is essentially free-form, but only break lines when you do want a line break at this point. In other words, don't wrap lines manually in the XML file: this will be automatically done by the software displaying the add-on description, according to the particular line width it uses (which can depend on the user's screen or configuration, etc.). A single \n inside a paragraph (see footnote [1]) means a hard line break. Two \n in a row (i.e., a blank line) should be used to separate paragraphs. Example:

This is a paragraph.

This is the second line of the same paragraph. It can be very, very, very long and contain several sentences.

This is a different paragraph. Again, don't break lines (i.e., don't press Enter) unless a particular line break is required.

Licensing terms =====

Nodes: /addon/license/designation

```
/addon/license/file
/addon/license/url
```

The `/addon/license/designation` node should describe the add-on licensing terms in a short but accurate way, if possible. If this is not practically doable, use the value `âCustomâ`. If the add-on is distributed under several licenses, use the value `âMultipleâ`. In all cases, make sure the licensing terms are clearly specified in other files of the add-on (typically, at least `README.txt` or `COPYING`). Values for `/addon/license/designation` could be `âGNU GPL version 2 or laterâ`, `âCCO 1.0 Universalâ`, `â3-clause BSDâ`, etc.

In most cases, the add-on should contain a file containing the full license text. Use the `/addon/license/file` node to point to this file: it should contain a file path that is relative to the add-on base directory. This path must use slash separators (`'/'`), even if you use Windows.

The `/addon/license/url` node should contain a single URL if there is an official, stable URL for the license under which the add-on is distributed. The term `âofficialâ` here is to be interpreted in the context of the particular license. For instance, for a GNU license (GPL2, LGPL2.1, etc.), the URL domain must be `gnu.org`; for a CC license (CCO 1.0 Universal, CC-BY-SA 4.0...), it must be `creativecommons.org`, etc.

Minimum and maximum FlightGear versions
=====

Nodes: `/addon/min-FG-version` and `/addon/max-FG-version`

These two nodes are optional and may be omitted unless the add-on is known not to work with particular FlightGear versions. `/addon/min-FG-version` defaults to `2017.4.0` and `/addon/max-FG-version` to the special value `'none'` (only allowed for `/addon/max-FG-version`). Apart from this special case, every non-empty value present in one of these two fields must be a proper FlightGear version number usable with `simgear::strutils::compare_versions()`, for instance `'2017.4.1'`.

Add-on version
=====

Node: `/addon/version`

The `/addon/version` node gives the version of the add-on and must obey a strict syntax[2], which is a subset of what is described in PEP 440:

<https://www.python.org/dev/peps/pep-0440/>

Valid examples are, in increasing sort order:

```
1.2.5.dev1      # first development release of 1.2.5
1.2.5.dev4      # fourth development release of 1.2.5
1.2.5
1.2.9
1.2.10a1.dev2   # second dev release of the first alpha release of 1.2.10
1.2.10a1        # first alpha release of 1.2.10
1.2.10b5        # fifth beta release of 1.2.10
1.2.10rc12      # twelfth release candidate for 1.2.10
1.2.10
1.3.0
2017.4.12a2
2017.4.12b1
```

2017.4.12rc1

2017.4.12

.devN suffixes can of course be used on beta and release candidates too, just as with the 1.2.10a1.dev2 example given above for an alpha release. Note that a development release always sorts before the corresponding non-development release (e.g., 2017.2.1b5.dev4 comes before 2017.2.1b5).

Translations

=====

Certain nodes can be translated based on the active languages within FlightGear. Especially, the name and descriptions can be translated, by adding them to a language node beneath 'localized', as show in the example above. Where there is no translation for a particular value, the default one is used.

Other fields

=====

The other nodes of 'addon-metadata.xml' should be self-explanatory. :-)

3. Add-ons and the Property Tree

~~~~~

#### a) Add-on metadata

~~~~~

The most important metadata for each registered add-on is made accessible in the Property Tree under /addons/by-id/ADDON_ID and the property /addons/by-id/ADDON_ID/loaded can be checked or listened to, in order to determine when a particular add-on is loaded. There is also a Nasal interface to access add-on metadata in a convenient way (see below).

More precisely, when an add-on is registered, its name, id, base path, version (converted to a string), loaded status (boolean) and load sequence number (int) become available in the Property Tree as /addons/by-id/ADDON_ID/{name,id,path,version,loaded,load-seq-num}. The loaded status is initially false, and set to true when the add-on loading phase is complete.

There are also /addons/addon[i]/path nodes where i is 0 for the first registered add-on, 1 for the second one, etc.

b) Subtree reserved for add-on developers

~~~~~

For each add-on, the subtree of the global Property Tree starting at /addons/by-id/ADDON\_ID/addon-devel is reserved for the specific needs of the add-on, where ADDON\_ID stands for the add-on identifier. For instance, developers of the add-on whose identifier is user.joe.FlyingTurtle can store whatever they want under /addons/by-id/user.joe.FlyingTurtle/addon-devel with the assurance that doing this won't clash with properties used by the add-on framework.

Example:

```
/addons/by-id/user.joe.FlyingTurtle/addon-devel/some/property and
/addons/by-id/user.joe.FlyingTurtle/addon-devel/other/property
```

could be two properties used for the specific needs of the

add-on whose identifier is user.joe.FlyingTurtle.

Add-on developers should *\*not\** use other places in the /addons subtree of the Property Tree for their custom properties.

#### 4. Resources under the add-on directory

~~~~~

Many functions in FlightGear use files that are located using the SimGear ResourceManager class. This class allows one to point to files by relative path in aircraft source files and other places. The resource manager queries a set of providers, some of which look inside aircraft paths (starting with the current aircraft), others inside scenery paths, others under \$FG_ROOT, etc. The first file that matches the specified resource path is used.

One of these providers only handles resource paths with a very specific syntax, which is:

[addon=ADDON_ID]path/relative/to/the/addon/directory

(for instance, [addon=user.joe.FlyingTurtle]images/eject-button.png)

When you use such a syntax in a place that is expected to contain a resource path, it will only find the specified file under the directory of the add-on whose identifier is ADDON_ID. This allows one to specifically target a particular file inside a particular add-on, instead of crossing fingers and hoping that the specified resource won't be found by coincidence in another place such as an aircraft directory, a scenery directory or inside \$FG_ROOT (such mistakes can easily happen when unrelated places use files with rather generic names, such as button.png, system.xml, etc.).

The [addon=ADDON_ID]relative/path syntax is useful where resources are specified inside non-Nasal files (e.g., in property-rule configuration files, which use the XML format). For the particular case of Nasal code, there is a better way that is explained below (see "Nasal API"): the resourcePath() method of addons.Addon objects returns a string like "[addon=ADDON_ID]relative/path" when you pass it the string "relative/path". This is a good thing to use, because then your Nasal code doesn't need to know about the particular syntax for add-on-specific resources and, more interestingly, doesn't have to hardcode the add-on identifier every time you need to access a resource inside the add-on directory.

4.1 Resources extending \$FG_ROOT

~~~~~

Add-ons can options supply a special sub-directory which is searched when FlightGear looks for files normally residing in \$FG\_ROOT. For example input configurations, network protocols and other non-aircraft resources. Since these files cannot use the scheme above, a different approach is used. If an add-on defines a subdirectory called 'FGData', this becomes an additional data directory to be searched for any such standard files. For security reasons, add-on FGData extensions are searched after the main \$FG\_ROOT location, so that an addon cannot maliciously replace a core resource.

Only some files currently support being added via this mechanism, so if you find a non-working case which would be useful, please request it via the developer mailing list.

## 5. Persistent storage location for add-ons

~~~~~

If an add-on needs to store data that persists across FlightGear sessions, it can use a specific directory tree whose path is obtained with `addon.storagePath`, where 'addon' is an `addons.Addon` instance. This corresponds to `$FG_HOME/Export/Addons/ADDON_ID`, however it is simpler and better to use `addon.storagePath` instead of hardcoding and manually assembling this path in each add-on. Since the directory is likely not to exist until the add-on creates it, the recommended usage pattern is the following:

- 1) Create the add-on-specific storage directory if it doesn't already exist, and optionally get its path at the same time:

```
storageDir = addon.createStorageDir();
```

Typically, you'll run this in the add-on `main()` function (at least, early enough) if your add-on uses the storage directory. Note that there is no need to check yourself whether the directory already exists: `addon.createStorageDir()` does that for you.

- 2) At any time, you can get a path to the add-on-specific storage directory with:

```
storageDir = addon.storagePath
```

Accessing `addon.storagePath` doesn't check for the existence nor the type of `$FG_HOME/Export/Addons/ADDON_ID`, thus it is a bit faster than `addon.createStorageDir()`. Use `addon.storagePath` whenever you know that the directory has already been created.

The features described in this section were added in FlightGear 2018.2.

6. Add-on-specific menus and dialogs

~~~~~

### a) Add-on-specific menus

~~~~~

Add-ons can easily provide their own menus. If an add-on is loaded that has a file named 'addon-menubar-items.xml' in its base directory, the menus described in this file are added to the FlightGear menu bar. The file should look like this:

```
<?xml version="1.0" encoding="UTF-8"?>
```

```
<PropertyList>
```

```
  <meta>
```

```
    <file-type type="string">FlightGear add-on menu bar items</file-type>
```

```
    <format-version type="int">1</format-version>
```

```
  </meta>
```

```
  <menubar-items>
```

```
    <menu>
```

```
      ...
```

```
    </menu>
```

```
    ...
```

```
  </menubar-items>
```

```
  ...
```

```

    </menu>
  </menubar-items>
</PropertyList>

```

In this file, each `<menu>` element must be a valid menu description for the FlightGear menu system (the FlightGear standard menubar in `$FG_ROOT/gui/menubar.xml` provides good examples). Here is an example that adds one menu with an entry for running some Nasal code and another entry for opening a custom dialog (see below for add-on-specific dialogs):

```

<menu>
  <label>My Menu</label>
  <enabled type="bool">true</enabled>

  <item>
    <label>Run Foobar Nasal</label>
    <binding>
      <command>nasal</command>
      <script>foobar.doBaz();</script>
    </binding>
  </item>

  <item>
    <label>My Foobar Dialog</label>
    <binding>
      <command>dialog-show</command>
      <dialog-name>my-foobar-dialog</dialog-name>
    </binding>
  </item>
</menu>

```

This feature was added in FlightGear 2018.2.

For older versions, one can add menus via `addon-config.xml`, but it's a bit hackish because of the menu index problem.

b) Add-on-specific dialogs

```

~~~~~

```

As is the case for aircraft, add-ons can provide their own dialogs by shipping the corresponding XML files in the subfolder `gui/dialogs` of the add-on base directory. In other words, with a file like

```

<addon-base-path>/gui/dialogs/my-foobar-dialog.xml

```

starting with:

```

<?xml version="1.0" encoding="UTF-8"?>
<PropertyList>
  <name>my-foobar-dialog</name>

```

```

...

```

the following `<item>` element inside `'addon-menubar-items.xml'` (see above) describes a valid menu entry for showing the custom dialog.

```

<item>
  <label>My Foobar Dialog</label>
  <binding>
    <command>dialog-show</command>
    <dialog-name>my-foobar-dialog</dialog-name>
  </binding>

```


</item>

See \$FG_ROOT/gui/dialogs to get inspiration from FlightGear's standard dialogs.

This feature was added in FlightGear 2018.2.

7. How to run code after an add-on is loaded

~~~~~

You may want to set up Nasal code to be run after an add-on is loaded; here is how to do that:

```
var addonId = "user.joe.FlyingTurtle";
var loadedFlagNode = props.globals.getNode("/addons")
    .getChild("by-id", 0, 1)
    .getChild(addonId, 0, 1)
    .getChild("loaded", 0, 1);

if (loadedFlagNode.getBoolValue()) {
    logprint(5, addonId ~ " is already loaded");
} else {
    # Define a function to be called after the add-on is loaded
    var id = setlistener(
        loadedFlagNode,
        func(changedNode, listenedNode) {
            if (listenedNode.getBoolValue()) {
                removelistener(id);
                logprint(5, addonId ~ " is loaded");
            };
        },
        0, 0);
}
```

## 8. Overview of the C++ API

~~~~~

The add-on C++ infrastructure mainly relies on the following classes: AddonManager, Addon and AddonVersion. AddonManager is used to register add-ons, which later leads to their loading. AddonManager relies on an `std::map<std::string, AddonRef>`, where keys are add-on identifiers and AddonRef is `SGSharedPtr<Addon>` at the time of this writing (changing it to another kind of smart pointer should be a mere one-line change). This map holds the metadata of each registered add-on. Accessor methods are available for:

- retrieving the lists of registered and loaded add-ons;
- checking if a particular add-on has already been registered or loaded;
- for each add-on, obtaining an Addon instance which can be queried for its identifier, its name, identifier, version, base path, the minimum and maximum FlightGear versions it requires, its base node in the Property Tree, its order in the load sequence...

The AddonVersion class handles everything about add-on version numbers:

- initialization from the individual components or from a string;
- conversion to a string and output to an `std::ostream`;
- access to every component;
- comparisons using the standard operators: `==`, `!=`, `<`, `<=`, `>`, `>=`.

Registering an add-on using `AddonManager::registerAddon()` ensures uniqueness of the add-on identifier and makes its name, identifier, base path, version (converted to a string), loaded status (boolean) and load sequence number (int) available in the Property Tree as `/addons/by-id/ADDON_ID/{name,id,path,version,loaded,load-seq-num}`.

Note: if C++ code needs to use the add-on base path, better use `AddonManager::addonBasePath()` or `Addon::getBasePath()`, whose return values can't be tampered with by Nasal code.

`AddonManager::registerAddon()` fails with a specific exception if the running FlightGear instance doesn't match the min-FG-version and max-FG-version requirements declared in the `addon-metadata.xml` file, as well as in the obvious other cases (required files such as `addon-metadata.xml` not found, invalid syntax in such files, etc.). The code in `options.cxx` (`fgOptAddon()`) catches such exceptions and displays the appropriate error message with `SG_LOG()` and `fatalMessageBoxThenExit()`.

9. Nasal API

~~~~~

The Nasal add-on API all lives in the 'addons' namespace. It gives Nasal code easy access to add-on metadata, for instance like this:

```
var myAddon = addons.getAddon("user.joe.FlyingTurtle");
print(myAddon.id);
print(myAddon.name);
print(myAddon.version.str());

foreach (var author; myAddon.authors) {
    print(author.name, " ", author.email, " ", author.url);
}

foreach (var maintainer; myAddon.maintainers) {
    print(maintainer.name, " ", maintainer.email, " ", maintainer.url);
}

print(myAddon.shortDescription);
print(myAddon.longDescription);
print(myAddon.licenseDesignation);
print(myAddon.licenseFile);
print(myAddon.licenseUrl);
print(myAddon.basePath);
print(myAddon.minFGVersionRequired);
print(myAddon.maxFGVersionRequired);
print(myAddon.homePage);
print(myAddon.downloadUrl);
print(myAddon.supportUrl);
print(myAddon.codeRepositoryUrl);

foreach (var tag; myAddon.tags) {
    print(tag);
}

print(myAddon.loadSequenceNumber);
# myAddon.node is a props.Node object for /addons/by-id/ADDON_ID
print(myAddon.node.getPath());
```

Among other things, the Nasal add-on API allows one to get the version of any registered add-on as a ghost and reliably compare it to another

instance of addons.AddonVersion:

```
var myAddon = addons.getAddon("user.joe.FlyingTurtle");
var firstVersionOK = addons.AddonVersion.new("2.12.5rc1");
# Or alternatively:
#   var firstVersionOK = addons.AddonVersion.new(2, 12, 5, "rc1");

if (myAddon.version.lowerThan(firstVersionOK)) {
    ...
}
```

Here follows the complete Nasal add-on API, at the time of this writing.  
All strings are encoded in UTF-8.

Queries to the AddonManager:

```
addons.isAddonRegistered(string addonId) -> bool (1 or 0)
addons.registeredAddons()                 -> vector<addons.Addon>
                                           (in registration/load order)
addons.isAddonLoaded(string addonId)      -> bool (1 or 0)
addons.loadedAddons()                     -> vector<addons.Addon>
                                           (in lexicographic order)
addons.getAddon(string addonId)           -> addons.Addon instance (ghost)
```

Read-only data members (attributes) of addons.Addon objects:

|                      |                                                                                                                            |
|----------------------|----------------------------------------------------------------------------------------------------------------------------|
| id                   | the add-on identifier, in reverse DNS style (string)                                                                       |
| name                 | the add-on "pretty name" (string)                                                                                          |
| version              | the add-on version (instance of addons.AddonVersion, ghost)                                                                |
| authors              | the add-on authors (vector of addons.Author ghosts)                                                                        |
| maintainers          | the add-on maintainers (vector of addons.Maintainer ghosts)                                                                |
| shortDescription     | the add-on short description (string)                                                                                      |
| longDescription      | the add-on long description (string)                                                                                       |
| licenseDesignation   | licensing terms: "GNU GPL version 2 or later", "CC0 1.0 Universal", etc. (string)                                          |
| licenseFile          | relative, slash-separated path to a file under the add-on base directory containing the license text (string)              |
| licenseUrl           | stable, official URL for the add-on license text (string)                                                                  |
| basePath             | path to the add-on base directory (string)                                                                                 |
| storagePath          | path to the add-on storage directory (string)<br>This is \$FG_HOME/Export/Addons/ADDON_ID.<br>[added in FlightGear 2018.2] |
| minFGVersionRequired | minimum required FG version for the add-on (string)                                                                        |
| maxFGVersionRequired | max. required FG version... or "none" (string)                                                                             |
| homePage             | add-on home page (string)                                                                                                  |
| downloadUrl          | add-on download URL (string)                                                                                               |
| supportUrl           | add-on support URL (string)                                                                                                |
| codeRepositoryUrl    | URL pointing to the development repository of the add-on (Git, Subversion, etc.; string)                                   |
| tags                 | vector containing the add-on tags used to help users find add-ons (vector of strings)                                      |
| node                 | base node for the add-on in the Property Tree: /addons/by-id/ADDON_ID (props.Node object)                                  |
| loadSequenceNumber   | 0 for the first registered add-on, 1 for the second one, etc. (integer)                                                    |

Member functions (methods) of addons.Addon objects:

```
createStorageDir() -> string
                  Create the add-on storage directory if it
```

doesn't already exist (that is, \$FG\_HOME/Export/Addons/ADDON\_ID). Return its path as a string.  
[added in FlightGear 2018.2]

resourcePath(string relPath) -> string

Return a resource path suitable for use with the simgear::ResourceManager. 'relPath' must be relative to the add-on base directory, and mustn't start with a '/'. You can use this method for instance to specify an image file for display in a Canvas widget.

In you want a full path to the resource file (e.g., for troubleshooting), call resolvepath() with the return value of addons.Addon.resourcePath().

Read-only data members (attributes) of addons.AddonVersion objects:

|             |                                                |
|-------------|------------------------------------------------|
| majorNumber | non-negative integer                           |
| minorNumber | non-negative integer                           |
| patchLevel  | non-negative integer                           |
| suffix      | string such as "", "a1", "b2.dev45", "rc12"... |

Member functions (methods) of addons.AddonVersion objects:

|                                                                 |                                |
|-----------------------------------------------------------------|--------------------------------|
| new(string version)                                             | construct from string          |
| new(int major, int minor=0, int patchLevel=0, string suffix="") | construct<br>  from components |
| str()                                                           | string representation          |
| equal(addons.AddonVersion other)                                |                                |
| nonEqual(addons.AddonVersion other)                             | compare to another             |
| lowerThan(addons.AddonVersion other)                            | addons.AddonVersion            |
| lowerThanOrEqual(addons.AddonVersion other)                     | instance                       |
| greaterThan(addons.AddonVersion other)                          |                                |
| greaterThanOrEqual(addons.AddonVersion other)                   |                                |

Read-only data members (attributes) of addons.Author objects:

|       |                                      |
|-------|--------------------------------------|
| name  | author name (non-empty string)       |
| email | email address of the author (string) |
| url   | home page of the author (string)     |

Read-only data members (attributes) of addons.Maintainer objects:

|       |                                                                                                                                                                              |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| name  | maintainer name (non-empty string)                                                                                                                                           |
| email | email address of the maintainer (string)                                                                                                                                     |
| url   | home page of the maintainer, if a person; if the maintainer is a mailing-list, the URL can point to a web page from which people can subscribe to that mailing-list (string) |

## 10. Add-on development; in-sim reload of Nasal code

---

!!! WARNING:  
 !!! The reload feature is meant for developers only, it should not be made  
 !!! visible to end users. Unexpected side effects may occur due to reload,  
 !!! if not implemented correctly.  
 !!! We really don't want users to send bug reports due to reload going wrong.

To make development of add-ons less time consuming, you can reload the Nasal part of your add-on without having to restart FlightGear. When an add-on is loaded, `setlistener()` and `maketimer()` wrappers are installed in the add-on's own namespace; these wrappers shadow and call themselves the standard `setlistener()` and `maketimer()` functions. The `setlistener()` and `maketimer()` wrapper functions keep track of every listener and timer they create. When the add-on is removed (e.g., as part of its reload sequence), `removelistener()` is called for each of these listeners, and each timer has its `stop()` method called.

-  
For the time being, you have to track any other resources outside the namespace of your add-on by yourself and clean them up in the `unload()` function, e.g. delete canvas or close any files you opened.

You can define this `unload()` function in the `addon-main.nas` file. When your add-on is reloaded, its `unload()` function, if defined, will be called with one argument: the `addons.Addon` object (a Nasal ghost) corresponding to your add-on. `unload()` is run in the add-on's own namespace.

In FlightGear Versions before 2020.1 the reload is triggered by setting the property `/addon/by-id/ADDON_ID/reload` to `true` (replace `ADDON_ID` with your particular add-on identifier).

```
!!! Since version 2020.1 reload should be done like this:
!!! fgcommand("addon-reload", props.Node.new({'id': 'ADDON_ID'}));
```

You can add a menu item to trigger the reload easily, but it should be removed before publishing your add-on to endusers (see the above warning).

Please have a look at the skeleton add-on at  
<https://sourceforge.net/p/flightgear/fgaddon/HEAD/tree/trunk/Addons/Skeleton/>

#### Footnotes

-----

- [1] `\n` represents end-of-line in string literals of languages such as C, C++, Python and many others. We use this convention here to represent the end-of-line character sequence in the XML data.
- [2] `MAJOR.MINOR.PATCHLEVEL[{a|b|rc}N1][.devN2]` where `MAJOR`, `MINOR` and `PATCHLEVEL` are non-negative integers, and `N1` and `N2` are positive integers.

## 4 Airspeed-indicator

The airspeed indicator can be initialized in an instrumentation.xml file.  
If not specified, the generic indicator will be loaded  
from the Aircraft/Generic/generic-instrumentation.xml.

The normal setup is :

```
<airspeed-indicator>
  <name>airspeed-indicator</name>
  <number>0</number>
  <total-pressure>/systems/pitot/total-pressure-inhg</total-pressure>
  <static-pressure>/systems/static/pressure-inhg</static-pressure>
  <has-overspeed-indicator>1</has-overspeed-indicator>
</airspeed-indicator>
```

Of course the total and static pressure may be sourced from any other  
pitot and static system when defined:

```
<airspeed-indicator>
  <name>airspeed-indicator</name>
  <number>1</number>
  <total-pressure>/systems/pitot[1]/total-pressure-inhg</total-pressure>
  <static-pressure>/systems/static[1]/pressure-inhg</static-pressure>
  <has-overspeed-indicator>0</has-overspeed-indicator>
</airspeed-indicator>
```

Note that the Aircraft/Generic/generic-systems.xml only initiates one  
pitot and one static system, see also README.systems

<total-pressure> is optional --- defaults to "/systems/pitot/total-pressure-inhg"  
For supersonic aircraft with an airspeed indicator NOT compensating for  
a shockwave in front of the pitot tube (most probably the case), use:  
<total-pressure>/systems/pitot/measured-total-pressure-inhg</total-pressure>

<static-pressure> is optional --- defaults to "/systems/static/pressure-inhg"  
<has-overspeed-indicator> is optional --- defaults to 0 / off

The <has-overspeed-indicator> provides a property for "barber-pole" animation,  
and is set to 0 / false by default ,

If enabled , these properties should be added in the aircraft -set file,  
with that aircraft's correct figures.

```
<airspeed-indicator>
  <ias-limit>248.0</ias-limit>
  <mach-limit>0.48</mach-limit>
  <alt-threshold>13200.0</alt-threshold>
</airspeed-indicator>
```

The default values are for a Beechcraft B1900D .

<ias-limit> is the aircraft's VNE (never exceed speed) in KIAS

<mach-limit> Mach speed limit.

<alt-threshold> altitude at which these figures were calculated.

Note : <mach-limit> is the mach limit at <alt-threshold>  
This was designed for indicated airspeed limits, but could probably be extended  
for mach limits.

To initiate additional airspeed indicators, add in your instrumentation file (for airspeed indicator index 1):

```
<airspeed-indicator>
  <name>airspeed-indicator</name>
  <number>1</number>
  <total-pressure>/systems/pitot[1]/total-pressure-inhg</total-pressure>
  <static-pressure>/systems/static[1]/pressure-inhg</static-pressure>
  <has-overspeed-indicator>0</has-overspeed-indicator>
</airspeed-indicator>
```

Note: this airspeed indicator sources its pressures from the second pitot and static system (with index 1).  
and in the aircraft -set file:

```
<airspeed-indicator n="1">
  <serviceable type="bool" archive="y">true</serviceable>
</airspeed-indicator>
```

And if "has-overspeed-indicator" = 1, the appropriate limits as explained above in the airspeed-indicator brackets.

## 5 Autopush

AUTOMATIC PUSHBACK FOR FLIGHTGEAR  
<http://gitlab.com/mdanil/flightgear-autopush>

Version 2.0.1

Copyright (c) 2018 Autopush authors:  
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Some of the code (c) FlightGear  
Distribute under the terms of GPLv2.

This project aims to develop a generic pushback for JSBSim and YASim aircraft, with the following characteristics.

1. Do the pushback procedure automatically.
2. Scale to different aircraft with minimum changes to their logic.
3. Use no computer resources in flight.

### INSTALLATION

Minimum FlightGear version: 2018.0

NOTE: these steps cover the minimal testing setup. To get the most realism out of Autopush, you will have to add logic aircraft-side as described in the last step.

1. Copy the autopush.config.xml.template into your aircraft directory and the Goldhofert.xml into <your-aircraft>/Models/Autopush/
2. Set up the pushback logic.

Add the following line under <sim><model> of your set.xml

```
<autopush include="autopush-config.xml"/>
```

Rename autopush-config.xml.template to autopush-config.xml and edit the file as described below.

Alternatively, you can copy the contents of autopush-config.xml.template to under <sim><model><autopush> of your set.xml and make these modifications there.

Change the aliases to point to the following data:

|                |                                                       |
|----------------|-------------------------------------------------------|
| steer-cmd-norm | nose wheel steering command norm                      |
| yaw            | nose wheel steering output norm or angle (see below)  |
| chocks         | chocks command bool (or leave it until step 7)        |
| available      | pushback availability bool (or leave it until step 7) |

Replace the MULTIPLIER in yaw-mult with:

|                    |                   |
|--------------------|-------------------|
| max steering angle | if yaw is norm    |
| 1.0                | if yaw is degrees |
| 57.3               | if yaw is radians |

Replace PITCH with the pushback's pitch relative to aircraft. If your aircraft's ground pitch varies greatly, you can make an alias to property with calculated relative pitch.



Replace MIN\_RADIUS with the minimum allowed turning radius in m of the center of the aircraft during pushback procedure.

NOTE: on some aircraft the turning radius is different for taxi and pushback. Please check the aircraft's literature.

Replace STOP\_DIST with the stopping distance in m from pushback speed.

Add under <nasal> of your set.xml:

```
<autopush>
  <file>Nasal/Autopush/autopush.nas</file>
</autopush>
<autopush_driver>
  <file>Nasal/Autopush/driver.nas</file>
</autopush_driver>
<dynarr>
  <file>Nasal/Autopush/dynarr.nas</file>
</dynarr>
<autopush_route>
  <file>Nasal/Autopush/route.nas</file>
</autopush_route>
```

Add under <sim><aircraft-data> of your set.xml:

```
<path>/sim/model/autopush/route/show</path>
<path>/sim/model/autopush/route/show-wingtip</path>
```

### 3. Connect the force to FDM.

#### 3.a. JSBSim:

3.a.1. Add the following under <external\_reactions> of your JSBSim XML.

```
<force name="tractor" frame="BODY">
  <location unit="M">
    <x>FRONT-X</x>
    <y>FRONT-Y</y>
    <z>FRONT-Z</z>
  </location>
  <direction>
    <x>1.0</x>
    <y>0.0</y>
    <z>0.0</z>
  </direction>
</force>
```

Replace FRONT-X, FRONT-Y, FRONT-Z with coordinates of your front bogey.

3.a.2. Add the following under <fdm><jsbsim><external\_reactions> of your set.xml.

```
<tractor>
  <magnitude alias="/sim/model/autopush/force-lbf"/>
  <x alias="/sim/model/autopush/force-x"/>
  <y alias="/sim/model/autopush/force-y"/>
  <z alias="/sim/model/autopush/force-z"/>
</tractor>
```

3.b. YASim. Add the following under <airplane> of your YASim xml.

```

<thruster x="FRONT-X" y="FRONT-Y" z="FRONT-Z" vx="1" vy="0" vz="0" thrust="100000.0">
  <control-input axis="/sim/model/autopush/force-x-yasim" control="THROTTLE" src0="-1" src1="1" dst0="-1" dst1="1">
</thruster>
<thruster x="FRONT-X" y="FRONT-Y" z="FRONT-Z" vx="0" vy="1" vz="0" thrust="100000.0">
  <control-input axis="/sim/model/autopush/force-y-yasim" control="THROTTLE" src0="-1" src1="1" dst0="-1" dst1="1">
</thruster>
<thruster x="FRONT-X" y="FRONT-Y" z="FRONT-Z" vx="0" vy="0" vz="1" thrust="100000.0">
  <control-input axis="/sim/model/autopush/force-z-yasim" control="THROTTLE" src0="-1" src1="1" dst0="-1" dst1="1">
</thruster>

```

Replace FRONT-X, FRONT-Y, FRONT-Z with coordinates of your front bogey.

4. Add the pushback model to your Model XML:

```

<model>
  <name>Pushback</name>
  <path>MODEL</path>
  <offsets>
    <x-m>FRONT-X</x-m>
    <y-m>FRONT-Y</y-m>
    <z-m>FRONT-Z</z-m>
  </offsets>
</model>

```

Replace FRONT-X, FRONT-Y, FRONT-Z with coordinates of your front bogey. Replace MODEL with one of the following file names:

Autopush/Goldhofert.xml for Goldhofer towbarless pushback

Edit the "SETTINGS" part in the beginning of the Goldhofert.xml to match your setup.

5. Add gui/dialogs/autopush.xml to your aircraft's menu (see FlightGear documentation for editing the menu).

6. If you have a bug tracker, please add a note, that autopush related bugs should be reported here:

<https://gitlab.com/mdanil/flightgear-autopush/issues>

7. Launch the simulator and try Autopush. After making sure it works, complete the support by implementing some logic in your aircraft and connecting the rest of the interface.

CAUTION.

1. Make sure to HAVE A BACK-UP COPY of your work.
  2. If anything is not clear in the instruction below, do not guess -- contact the authors.
- 7.1. When pushback is connected ("/sim/model/autopush/connected"), nose wheel steering must actuate at different speed, depending on its rollspeed. The exact dependency is different per aircraft and used pushback visual, and for most aircraft the only way to find it is trial and error until it "looks right":
- the input must be taken from pushback steering command norm (set by autopush-config.xml, default: "/controls/flight/rudder");
  - the output must be written to pushback orientation in degrees, radians or norm (set by autopush-config.xml, default: "/gear/gear[0]/steering-norm").

- 7.2. Set or alias (in autopush-config.xml) the availability property `"/sim/model/autopush/available"`. It must be false if e.g. the aircraft is moving too fast, the front wheel is not touching the ground, the aircraft is damaged or is outside of an airport etc.
- 7.3. Make Autopush remove wheel chocks by setting the alias in autopush-config.xml to the chocks property. (default: `"/controls/gear/wheel-chocks"`).
- 7.4. Optionally, Autopush may be made visible in multiplayer by duplicating the properties used in its model.xml into some unused MP properties. See the list in

<https://sourceforge.net/p/flightgear/flightgear/ci/next/tree/src/MultiPlayer/multiplaymgr.cxx>

around line 215, and then using those properties in the "SETTINGS" part of Autopush model.xml.

After making these changes check the Autopush model.xml's settings and make sure they match the setup. Launch the simulator and try Autopush.

## TUNING

There should normally be no need to change the coefficients, because the inertia of different aircraft is already taken into account. But the gear setup may differ enough to require some tuning.

If these settings are changed during simulation, they take effect after disconnecting and reconnecting the pushback.

Pushback (/sim/model/autopush):

| Coefficient | Unit                                                    | Description                                                                                                                                   |
|-------------|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| K_p         | $((\text{km/h})/\text{s})/(\text{km/h})$                | Proportional coefficient of PID. Defines the start/stop throttle and immediate response to speed difference $\Delta V = V_{\text{set}} - V$ . |
| F_p         | $(\text{km/h})/\text{s}$                                | Proportional clipping.                                                                                                                        |
| K_i         | $((\text{km/h})/\text{s})/((\text{km/h})\cdot\text{s})$ | Integral coefficient of PID. Defines how fast the steady throttle is ramped during the push.                                                  |
| F_i         | $(\text{km/h})/\text{s}$                                | Integral clipping.                                                                                                                            |
| K_d         | $-((\text{km/h})/\text{s})/((\text{km/h})/\text{s})$    | Differential coefficient of PID. Stabilizes the approaching of steady throttle.                                                               |
| F_d         | $(\text{km/h})/\text{s}$                                | Differential clipping.                                                                                                                        |

Pushback driver (/sim/model/autopush/driver):

| Coefficient | Unit  | Description                                |
|-------------|-------|--------------------------------------------|
| F_V         | km/h  | Max towing speed in auto mode.             |
| K_psi       | 1/deg | Amount of steering per heading correction. |

|            |            |                                                             |
|------------|------------|-------------------------------------------------------------|
| F_psi      | 1/deg      | Max steering per heading correction.                        |
| K_deltapsi | -1/(deg/s) | Amount of steering compensation per heading derivative.     |
| F_psi      | 1/(deg/s)  | Max amount of steering compensation per heading derivative. |

## 6 Checklists

### CHECKLISTS

You can create one or more checklist for an aircraft under `/sim/checklists`. These are intended to mimic the checklists of aircraft themselves, and can be found under the Help->Checklists menu within the simulator.

Tutorials are automatically generated from checklists on startup.

Each checklist is defined as a property tree under `/sim/checklists/checklist[n]` or `/sim/checklists/group[n]/checklist[m]`

with the following tags

- `<title>` - Name of the checklist
- `<auto-tutorial>` - Whether a tutorial should be automatically generated (true, default) or not (false).
- `<page>` - Zero or more pages for the checklist containing:
  - `<item>` - One or more checklist items containing:
    - `<name>` - name of the checklist item (e.g. Carb Heat), to appear on the left
    - `<value>` - One or more values for the checklist item, to appear on the right hand side
    - `<marker>` - A tutorial marker (displayed when the user presses the ? button) This can be easily placed using the Help->Display Tutorial Marker. Contains x-m, y-m, z-m and scale tag.
    - `<condition>` - Optional standard FlightGear condition node that evaluates when the checklist item has been completed.
    - `<binding>` - Zero or more bindings to execute the checklist item. Allows the user to have their virtual co-pilot perform the action if they select the ">" button next to the checklist item.

The `<page>` tag may be omitted for single-page checklists, with the `<item>` tags immediately under the `<checklist[n]>` node.

Tutorial auto-generation of all checklists can be disabled by setting `/sim/checklists/auto-tutorials=false`.

Checklists may be grouped under `<group>` nodes with a `<name>` tag describing the group. For example

```
<group>
  <name>Emergency</name>
  <auto-tutorial>false</auto-tutorial>
  <checklist>...
  <checklist>...
</group>
<group>
  <name>Normal</name>
  <auto-tutorial>true</auto-tutorial>
  <checklist>...
  <checklist>...
</group>
```

See the `c172p` for an example of this in action (`Aircraft/c172p/c172-checklists.xml`).

## 7 Commands

FlightGear Commands Mini-HOWTO

David Megginson

Started: 2002-10-25

Last revised: 2007-12-01

In FlightGear, a *\*command\** represents an action, while a *\*property\** represents a state. The trigger for a command can be any kind of user input, including the keyboard, mouse, joystick, GUI, instrument panel, or a remote network client.

XML Command Binding Markup

Most of the command-binding in FlightGear is handled through static XML configuration files such as \$FG\_ROOT/keyboard.xml for the keyboard, \$FG\_ROOT/mice.xml for the mouse, and \$FG\_ROOT/gui/menubar.xml for the menubar. In all of these files, you reference a command through a binding. This binding advances the first throttle by 1%, up to a maximum value of 1.0:

```
<binding>
  <command>property-adjust</command>
  <property>/controls/throttle[0]</property>
  <step type="double">0.01</step>
  <max>1.0</max>
</binding>
```

A command binding always consists of the XML 'binding' element, with one subelement named 'command' containing the command name (such as 'property-adjust'). All other subelements are named parameters to the command: in this case, the parameters are 'property', 'step', and 'max'. Here is a simpler binding, with no parameters:

```
<binding>
  <command>exit</command>
</binding>
```

Bindings always appear inside some other kind of markup, depending on the input type. For example, here is the binding from keyboard.xml that links the ESC key to the 'exit' command:

```
<key n="27">
  <name>ESC</name>
  <desc>Prompt and quit FlightGear.</desc>
  <binding>
    <command>exit</command>
  </binding>
</key>
```

Usually, more than one binding is allowed for a single input trigger, and bindings are executed in order from first to last. Bindings support conditions (see README.conditions):

```
<key n="113">
  <name>q</name>
  <desc>Test</desc>

  <binding>
```

```

<condition>
  <property>/devices/status/mice/mouse/button[0]</property>
</condition>
<command>nasal</command>
<script>print("mouse button 0 pressed")</script>
</binding>
</key>

```

Keyboard definitions can embed bindings in tags <mod-up> (key released), <mod-shift>, <mod-ctrl>, <mod-alt>, <mod-meta>, <mod-super>, and <mod-hyper>. Nesting is supported. Meta, Super, and Hyper modifier tags are for local use only, and must be supported by the operating system to work.

```

<key n="113">
  <name>q</name>
  <desc>Test</desc>
  <binding>
    <command>nasal</command>
    <script>print("q pressed")</script>
  </binding>

  <mod-alt>
    <binding>
      <command>nasal</command>
      <script>print("Alt-q pressed")</script>
    </binding>

    <mod-super>
      <binding>
        <command>nasal</command>
        <script>print("Alt-Super-q pressed")</script>
      </binding>

      <mod-meta>
        <binding>
          <command>nasal</command>
          <script>print("Alt-Super-Meta-q pressed")</script>
        </binding>

      </mod-meta>
    </mod-super>
  </mod-alt>
</key>

```

## Built-in Commands

-----

As of the last revision date, the following commands were available from inside FlightGear; the most commonly-used ones are the commands that operate on property values (FlightGear's internal state):

null - do nothing

script - execute a PSL script  
 script: the PSL script to execute

exit - prompt and quit FlightGear

pause - pause/resume the simulation

load - load properties from an XML file  
 file: the name of the file to load, relative to the current directory (defaults to "fgfs.sav")

save - save properties to an XML file  
 file: the name of the file to save, relative to the current directory (defaults to "fgfs.sav").

loadxml - load XML file into property tree  
 filename: the path & filename of the file to load  
 targetnode: the target node within the property tree where to store the XML file's structure. If targetnode isn't defined, then the data will be stored in a node "data" under the argument branch.

savexml - save property tree node to XML file  
 filename: the path & filename for the file to be saved  
 sourcenode: the source node within the property tree where the XML file's structure is assembled from. If sourcenode isn't defined, then savexml will try to save data stored in a node "data" in the argument branch.

panel-load - (re)load the 2D instrument panel  
 path: the path of the XML panel file, relative to \$FG\_ROOT (defaults to the value of /sim/panel/path if specified, or "Panels/Default/default.xml" as a last resort.

panel-mouse-click - pass a mouse click to the instrument panel  
 button: the number of the mouse button (0-based)  
 is-down: true if the button is down, false if it is up  
 x-pos: the x position of the mouse click  
 y-pos: the y position of the mouse click

preferences-load - (re)load preferences  
 path: the file name to load preferences from, relative to \$FG\_ROOT.  
 Defaults to "preferences.xml".

view-cycle - cycle to the next viewpoint

screen-capture - capture the screen to a file

tile-cache-reload - reload the scenery tile cache

lighting-update - update FlightGear's lighting

property-toggle - swap a property value between true and false  
 property: the name of the property to toggle

property-assign - assign a value to a property  
 property[0]: the name of the property that will get the new value.  
 value: the new value for the property; or  
 property[1]: the name of the property holding the new value.

property-interpolate - assign a value to a property, interpolated over time  
 property[0]: the name of the property that will get the new value and defines the starting point of the interpolation  
 value: the new value for the property; or  
 property[1]: the name of the property holding the new value.  
 time: the time in seconds it takes for the transition from the old value to the new value of property[0]; or  
 rate: the ammount of change per second the value of property[0] changes to transition to the new value

property-adjust - adjust the value of a property



property: the name of the property to increment or decrement  
step: the amount of the increment or decrement (defaults to 0)  
offset: input offset distance (used for the mouse; multiplied by factor)  
factor: factor for multiplying offset distance (used for the mouse; defaults to 1)  
min: the minimum allowed value (default: no minimum)  
max: the maximum allowed value (default: no maximum)  
mask: 'integer' to apply only to the left of the decimal point; 'decimal' to apply only to the right of the decimal point; 'all' to apply to the full value (defaults to 'all')  
wrap: true if the value should be wrapped when it passes min or max; both min and max must be specified (defaults to false)

property-multiply - multiply the value of a property

property: the name of the property to multiply  
factor: the amount by which to multiply (defaults to 1.0)  
min: the minimum allowed value (default: no minimum)  
max: the maximum allowed value (default: no maximum)  
mask: 'integer' to apply only to the left of the decimal point; 'decimal' to apply only to the right of the decimal point; 'all' to apply to the full value (defaults to 'all')  
wrap: true if the value should be wrapped when it passes min or max; both min and max must be specified (defaults to false)

property-swap - swap the values of two properties

property[0]: the name of the first property  
property[1]: the name of the second property

property-scale - set the value of a property based on an axis

property: the name of the property to set  
setting: the current input setting (usually a joystick axis from -1 or 0 to 1)  
offset: the offset to shift by, before applying the factor (defaults to 0)  
factor: the factor to multiply by (use negative to reverse; defaults to 1.0)  
squared: if true will square the resulting value (same as power=2)  
power: the resulting value will be taken to the power of this integer value (overrides squared; default=1)

property-cycle - cycle a property through a set of values

property: the name of the property to cycle  
value[\*]: all of the allowed values

dialog-new - create new dialog from the argument branch

dialog-show - show an XML-configured dialog box

dialog-name - the name of the dialog to show

dialog-close - close the active dialog box

dialog-update - copy values from FlightGear to the active dialog box

object-name: the name of the GUI object to update (defaults to all objects)

dialog-apply - copy values from the active dialog box to FlightGear

object-name: the name of the GUI object to apply (defaults to all objects)

presets-commit - commit preset values from /sim/presets

open-browser - open the web browser and show given file

path: name of the local file to be opened.  
url: URL to be opened (http://..., ftp://...).

The following commands are temporary, and will soon disappear or be renamed; do NOT rely on them:

old-save-dialog - offer to save a flight  
old-load-dialog - offer to load a flight  
old-reinit-dialog - offer to reinit FlightGear  
old-hires-snapshot-dialog - save a hires screen shot  
old-snapshot-dialog - save a screenshot  
old-print-dialog - print the screen (Windows only)  
old-pilot-offset-dialog - set pilot offsets graphically  
old-hud-alpha-dialog - set the alpha value for the HUD  
old-properties-dialog - display the property browser  
old-preset-airport-dialog - set the default airport  
old-preset-runway-dialog - set the default runway  
old-preset-offset-distance-dialog - set the default offset distance  
old-preset-altitude-dialog - set the default altitude  
old-preset-glidescope-dialog - set the default glidescope  
old-preset-airspeed-dialog - set the default airspeed  
old-preset-commit-dialog - commit preset values  
old-ap-add-waypoint-dialog - add a waypoint to the current route  
old-ap-pop-waypoint-dialog - remove a waypoint from the current route  
old-ap-clear-dialog - clear the current route  
old-ap-adjust-dialog - adjust the autopilot settings  
old-lat-lon-format-dialog - toggle the lat/lon format in the HUD

#### Adding New Commands in C++

-----

To add a new command to FlightGear, you first need to create a function that takes a single SGPropertyNode const pointer as an argument:

```
void  
do_something (SGPropertyNode * arg)  
{  
    something();  
}
```

Next, you need to register it with the command manager:

```
globals->get_commands()->addCommand("something", do_something);
```

Now, the command "something" is available to any mouse, joystick, panel, or keyboard bindings. If the bindings pass any arguments, they will be children of the SGPropertyNode passed in:

```
void  
do_something (const SGPropertyNode * arg)  
{  
    something(arg->getStringValue("foo"), arg->getDoubleValue("bar"));  
}
```

That's pretty-much it. Apologies in advance for not making things any more complicated.

## 8 Conditions

### CONDITIONS IN FLIGHTGEAR PROPERTY FILES

Written by David Megginson, david@megginson.com  
Last modified: \$Date\$

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#### 1. Introduction

Some FlightGear property files contain conditions, affecting whether bindings or animations are applied. For example, the following binding will apply only when the /sim/input/selected/engine[0] property is true:

```
<binding>
  <condition>
    <property>/sim/input/selected/engine[0]</property>
  </condition>
  <command>property-assign</command>
  <property>/controls/starter[0]</property>
  <value type="bool">true</value>
</binding>
```

Conditions always occur within a property subtree named "condition", which is equivalent to an "and" condition.

#### 2. Comparison Operators

The simplest condition is "property". It resolves as true when the specified property has a boolean value of true (i.e. non-zero, etc.) and false otherwise. Here is an example:

```
<condition>
  <property>/sim/input/selected/engine[0]</property>
</condition>
```

For more sophisticated tests, you can use the "less-than", "less-than-equals", "greater-than", "greater-than-equals", "equals", and "not-equals" comparison operators. These all take two operands, either two "property" operands or one "property" and one "value" operand, and return true or false depending on the result of the comparison. The value of the second operand is always forced to the type of the first; for example, if you compare a string and a double, the double will be forced to a string and lexically compared. If one of the operands is a property, it is always assumed to be first. Here is an example of a comparison that is true only if the RPM of the engine is less than 1500:

```
<condition>
  <less-than>
    <property>/engines/engine[0]/rpm</property>
    <value>1500</value>
  </less-than>
</condition>
```

#### 3. Boolean Operators

-----

Finally, there are the regular boolean operators "and", "or", and "not". Each one surrounds a group of other conditions, and these can be nested to arbitrary depths. Here is an example:

```
<condition>
  <and>
    <or>
      <less-than>
        <property>/engines/engine[0]/rpm</property>
        <value>1500</value>
      </less-than>
      <greater-than>
        <property>/engines/engine[0]/rpm</property>
        <value>2500</value>
      </greater-than>
    </or>
    <property>/engines/engine[0]/running</property>
  </and>
</condition>
```

The top-level "condition" is an implicit "and".

#### 4. Approximating if...else

-----

There is no equivalent to the regular programming 'else' statement in FlightGear conditions; instead, each condition separately must take the others into account. For example, the equivalent of

```
if (x == 3) ... else if (y == 5) ... else ...
```

in FlightGear conditions is

```
<condition>
  <equals>
    <property>/x</property>
    <value>3</value>
  </equals>
  <not>
    <equals>
      <property>/y</property>
      <value>5</value>
    </equals>
  </not>
</condition>
```

and then

```
<condition>
  <equals>
    <property>/y</property>
    <value>5</value>
  </equals>
  <not>
    <equals>
      <property>/x</property>
      <value>3</value>
    </equals>
  </not>
</condition>
```

and then

```
<condition>
  <not>
    <equals>
      <property>/x</property>
      <value>3</value>
    </equals>
  </not>
  <not>
    <equals>
      <property>/y</property>
      <value>5</value>
    </equals>
  </not>
</condition>
```

It's verbose, but it works nicely within existing property-based formats and provides a lot of flexibility.

## 5. Syntax Summary

-----

Here's a quick syntax summary:

\* `<and>...</and>`

Contains one or more subconditions, all of which must be true.

\* `<condition>...</condition>`

The top-level container for conditions, equivalent to an "and" group

\* `<equals>...</equals>`

Contains two properties or a property and value, and is true if the properties have equivalent values.

\* `<not-equals>...</not-equals>`

Contains two properties or a property and value, and is true if the properties have different values.

\* `<greater-than>...</greater-than>`

Contains two properties or a property and a value, and is true if the second property or the value has a value greater than the first property.

\* `<greater-than-equals>...</greater-than-equals>`

Contains two properties or a property and a value, and is true if the second property or the value has a value greater than or equal to the first property.

\* `<less-than>...</less-than>`

Contains two properties or a property and a value, and is true if the second property or the value has a value less than the first property.

\* <less-than-equals>...</less-than-equals>

Contains two properties or a property and a value, and is true if the second property or the value has a value less than or equal to the first property.

\* <not>...</not>

Contains one subcondition, which must not be true.

\* <not-equals>...</not-equals>

Contains two properties or a property and value, and is true if the properties do not have equivalent values.

\* <or>...</or>

Contains one or more subconditions, at least one of which must be true.

\* <property>...</property>

The name of a property to test.

\* <value>...</value>

A literal value in a comparison.

## 9 Digitalfilters

### COMMON SETTINGS

Currently four types of digital filter implementations are supported. They all serve an individual purpose or are individual implementations of a specific filter type. Each filter implementation uses the same set of basic configuration tags and individual configuration elements. These individual elements are described in the section of the filter.

#### The InputValue

Each filter has several driving values, like the input value itself, sometimes a reference value, a gain value and others. Most of these input values can be either a constant value or the value of a property. They all use the same syntax and will be referred to as InputValue in the remaining document.

The complete XML syntax for a InputValue is

```
<some-element>
  <condition>
    <!-- any condition as defined in README.conditions -->
  </condition>
  <property>/some/property/name</property>
  <value>0.0</value>
  <scale>1.0</value>
  <offset>0.0</offset>
  <max>infinity</max>
  <min>-infinity<min>
  <abs>false</abs>
  <period>
    <min>-180.0</min>
    <max>-180.0</max>
  </period>
</some-element>
```

The enclosing element `<some-element>` is the element defined in each filter, like `<input>`, `<u_min>`, `<reference>` etc. These elements will be described later. The value of the input is calculated based on the given value, scale and offset as  $\text{value} * \text{scale} + \text{offset}$  and the result is clipped to min/max, if given. With the full set of given elements, the InputValue will initialize the named property to the value given, reduced by the given offset and reverse scaled by the given scale.

Example:

```
<input>
  <property>/controls/flight/rudder</property>
  <value>0.0</value>
  <scale>0.5</scale>
  <offset>0.5</offset>
</input>
```

Will use the property `/controls/flight/rudder` as the input of the filter. The property will be initialized at a value of zero and since the property usually is in the range `[-1..+1]`, the the value of `<input>` will be in the range  $(-1)*0.5+0.5$  to  $(+1)*0.5+0.5$  which is `[0..1]`.

The default values for elements not given are:

```
<value/> : 0.0
<scale/> : 1.0
<offset/>: 0.0
```



```

<property/> : none
<min/>      : unclipped
<max/>      : unclipped
<abs/>      : false

```

Some examples:

```

<input>
  <property>/position/altitude-ft</property>
  <scale>0.3048</scale>
</input>

```

Gives the altitude in meters. No initialization of the property is performed, no offset applied.

```

<reference>
  <value>0.0</value>
</reference>

```

A constant reference of zero.

A abbreviated method of defining values exist for using a just constant or a property. The above example may be written as

```
<reference>0.0</reference>
```

Or if the reference is defined in a property

```
<reference>/some/property/name</reference>
```

No initialization, scaling or offsetting is performed here.

The logic behind this is: If the text node in the element (the text between the opening and closing tag) can be converted to a double value, it will be interpreted as a double value. Otherwise the text will be interpreted as a property name.

Examples:

```

<reference>3.1415927</reference>          - The constant of PI (roughly)
<reference>/position/altitude-ft</reference> - The property /position/altitude-ft
<reference>3kings</reference>              - The constant 3. The word kings is
                                           ignored
<reference>food4less</reference>          - The property food4less

```

The <property> element may also be written as <prop> for backward compatibility.

There may be one or more InputValues for the same input of a filter which may be bound to conditions. Each InputValue will have its condition checked in the order of InputValues given in the configuration file. The first InputValue that returns true for its condition will be evaluated. Chaining a number of InputValues with conditions and an unconditioned InputValue works like the C language equivalent

```

if( condition ) {
  // compute value of first element
} else if( condition2 ) {
  // compute value of second element
} else if( condition3 ) {
  // compute value of third element
} else {
  // compute value of last element
}

```

Example: Set the gain to 3.0 if /autopilot/locks/heading equals dg-heading-hold or 2.0 otherwise.

```

<digital-filter>
  <gain>
    <condition>
      <equals>
        <property>/autopilot/locks/heading</property>
        <value>dg-heading-hold</value>
      </equals>
    </condition>
    <value>3.0</value>
  </gain>
</digital-filter>

```

```

    <gain>
    <!-- Hint: omit a condition here as a fallthru else condition -->
  </gain>
    <value>2.0</value>
  <gain>
</digital-filter>

```

If the element `<abs>` is used and set to the value "true", only the absolute value of the input (the positive part) is used for further computations. The `abs` function is applied after all other computations are completed.

## OutputValue

```
=====
```

Each filter drives one to many output properties. No scaling or offsetting is implemented for the output value, these should be done in the filter itself. The output properties are defined in the `<output/>` element by adding `<property/>` elements within the `<output/>` element. For just a single output property, the `<property/>` element may be omitted. For backward compatibility, `<property/>` may be replaced by `<prop/>`. Non-existing properties will be created with type double.

Example: (Multiple output properties)

```

<output>
  <property>/some/output/property</property>
  <property>/some/other/output/property</property>
  <property>/and/another/output/property</property>
</output>

```

Example: a single output property

```
<output>/just/a/single/property</output>
```

## Other Common Settings

```
=====
```

|                           |        |                                                 |
|---------------------------|--------|-------------------------------------------------|
| <code>&lt;name&gt;</code> | String | The name of the filter. Used for debug purpose. |
|---------------------------|--------|-------------------------------------------------|

Example:

```
<name>pressure rate filter</name>
```

  

|                                                          |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>&lt;debug&gt;</code>                               | Boolean    | If true, this filter puts out debug information when updated. Example: <code>&lt;debug&gt;&gt;false&lt;/debug&gt;</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <code>&lt;input&gt;</code>                               | InputValue | The input property driving the filter. Refer to InputValue for details.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <code>&lt;reference&gt;</code>                           | InputValue | The reference property for filter that need one. Refer to InputValue for details.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <code>&lt;output&gt;</code>                              | Complex    | Each filter can drive one to many output properties. Refer to OutputValue for details.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <code>&lt;u_min&gt;</code><br><code>&lt;u_max&gt;</code> | InputValue | This defines the optional minimum and maximum value the output is clamped to. If neither <code>&lt;u_min&gt;</code> nor <code>&lt;u_max&gt;</code> exists, the output is only limited by the internal limit of double precision float computation. If either <code>&lt;u_min&gt;</code> or <code>&lt;u_max&gt;</code> is given, clamping is activated. A missing min or max value defaults to 0 (zero).<br>Note: <code>&lt;u_min&gt;</code> and <code>&lt;u_max&gt;</code> may also occur within a <code>&lt;config&gt;</code> element. <code>&lt;min&gt;</code> and <code>&lt;max&gt;</code> may be used as a substitute for the corresponding <code>u_xxx</code> element. |
| <code>&lt;period&gt;</code>                              | Complex    | Define a periodical input or output value. The phase width is defined by the child elements <code>&lt;min&gt;</code> and <code>&lt;max&gt;</code> which are of type InputValue                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

Example: Limit the pilot's body temperature to a constant minimum of 36 and a maximum defined in `/pilots/max-body-temperature-degc`, initialized to 40.0

```

<u_max>
  <prop>/pilots/max-body-temperature-degc</prop>
  <value>40.0</value>
</u_max>
<min>
  <value>36.0</value>
</min>

```

Implicit definition of the minimum value of 0 (zero) and defining a maximum of 100.0

```

<config>
  <u_max>100.0</u_max>
</config>

```

This defines the input or output as a periodic value with a phase width of 360, like the compass rose. Any value reaching the filter's input or leaving the filter at the output will be transformed to fit into the given range by adding or subtracting one phase width of 360. Values of -270, 90 or 450 applied to this periodical element will always result in +90. A value of 630, 270 or -90 will be normalized to -90 in the given example.

```

<period>
  <min>-180.0</min>
  <max>180.0</max>
</period>

```

|                       |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>&lt;enable&gt;</b> | <b>Complex</b> | <p>Define a condition to enable or disable the filter. For disabled filters, no output computations are performed. Only enabled filters fill the output properties. The default for undefined conditions is enabled.</p> <p>Several way exist to define a condition. The most simple case is checking a boolean property. For this, just a &lt;prop&gt; element naming this boolean property is needed. The boolean value of the named property defines the enabled state of the filter. To compare the value of a property with a constant, a &lt;prop&gt; and a &lt;value&gt; element define the property name and the value to be compared. The filter is enabled, if the value of the property equals the given value. A case sensitive string compare is performed here.</p> <p>To define more complex conditions, a &lt;condition&gt; element may be used to define any condition described in README.conditions. If a &lt;condition&gt; element is present and if it contains a valid condition, this conditions has precedence over a given &lt;prop&gt;/&lt;value&gt; condition.</p> <p>The child element &lt;honor-passive&gt;, a boolean flag, may be present within the &lt;enable&gt; element. If this element is true, the property /autopilot/locks/passive-mode is checked and if it is true, the filter output is computed, but the output properties are not set. The default for honor-passive is false</p> |
|-----------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Example: Check a boolean property, only compute this filter if gear-down is true and /autopilot/locks/passive-mode is false

```

<enable>
  <prop>/gear/gear-down</prop>
  <honor-passive>true</honor-passive>
</enable>

```

Check a property for equality, only compute this filter if the autopilot is locked in heading mode.

```

<enable>
  <prop>/autopilot/locks/heading</prop>
  <value>dg-heading-hold</value>
</enable>

```

Use a complex condition, only compute this filter if the autopilot is serviceable and the lock is either dg-heading-hold or nav1-heading-hold

```
<enable>
  <condition>
    <property>/autopilo/serviceable</property>
    <or>
      <equals>
        <property>/autopilot/locks/heading</property>
        <value>dg-heading-hold</value>
      </equals>
      <equals>
        <property>/autopilot/locks/heading</property>
        <value>nav1-heading-hold</value>
      </equals>
    </or>
  </condition>
</enable>
```

## INDIVIDUAL FILTER CONFIGURATION

### Digital Filter

Six different types of digital filter can be configured inside the autopilot configuration file. There are four low-pass filter types and two gain filter types.

The low-pass filter types are:

- \* Exponential
- \* Double exponential
- \* Moving average
- \* Noise spike filter

The gain filter types are:

- \* gain
- \* reciprocal

To add a digital filter, place a <filter> element under the root element. Next to the global configuration elements described above, the following elements configure the digital filter:

<filter-time> InputValue This tag is only applicable for the exponential and double-exponential filter types. It controls the bandwidth of the filter. The bandwidth in Hz of the filter is:  $1/\text{filter-time}$ . So a low-pass filter with a bandwidth of 10Hz would have a filter time of  $1/10 = 0.1$

<samples> InputValue This tag only makes sense for the moving-average filter. It says how many past samples to average.

<max-rate-of-change> InputValue This tag is applicable for the noise-spike filter. It says how much the value is allowed to change per second.

<gain> InputValue This is only applicable to the gain and reciprocal filter types. The output for gain filter is computed as  $\text{input} \times \text{gain}$  while the reciprocal filter computes output as  $\text{gain}/\text{input}$  for input values  $\neq 0$  (zero). Gain may be a constant, a property name defined by a <prop> element within the <gain> element or a property name initialized to a value by using

a <prop> and <value> element.

Example: a pressure-rate-filter implemented as a double exponential low pass filter with a bandwidth of 10Hz

```
<filter>
  <name>pressure-rate-filter</name>
  <debug>false</debug>
  <type>double-exponential</type>
  <enable>
    <prop>/autopilot/locks/pressure-rate-filter</prop>
    <value>true</value>
  </enable>
  <input>/autopilot/internal/pressure-rate</input>
  <output>/autopilot/internal/filtered-pressure-rate</output>
  <filter-time>0.1</filter-time>
</filter>
```

This will filter the pressure-rate property. The output will be to a new property called filtered-pressure-rate. You can select any numerical property from the property tree. The input property will not be affected by the filter, it will stay the same as it would if no filter was configured.

Example 2:

```
<filter>
  <name>airspeed elevator-trim gain reciprocal filter</name>
  <debug>false</debug>
  <enable>
    <prop>/autopilot/locks/airspeed-elevator-trim-gain</prop>
    <value>true</value>
  </enable>
  <type>reciprocal</type>
  <gain>
    <prop>/autopilot/settings/elevator-trim-airspeed-reciprocal-gain</prop>
    <value>7</value>
  </gain>
  <input>/velocities/airspeed-kt</input>
  <output>/autopilot/internal/elevator-trim-gain</output>
  <u_min>0.005</u_min>
  <u_max>0.02</u_max>
</filter>
```

This will use the /velocities/airspeed-kt property to produce a gain factor that reduces as airspeed increases. At airspeeds up to 350kt the gain will be clamped to 0.02, at 700kt the gain will be 0.01 and at 1400kt the gain will be 0.005. The gain will be clamped to 0.005 for airspeeds > 1400kt.

The output from this filter could then be used to control the gain in a PID controller:

```
<pid-controller>
  <name>Pitch hold</name>
  <debug>false</debug>
  <enable>
    <prop>/autopilot/locks/pitch</prop>
    <value>true</value>
  </enable>
  <input>
    <prop>/orientation/pitch-deg</prop>
  </input>
  <reference>
    <prop>/autopilot/settings/target-pitch-deg</prop>
  </reference>
```

```

</reference>
<output>
  <prop>/autopilot/internal/target-elevator-trim-norm</prop>
</output>
<config>
  <Ts>0.05</Ts>
  <Kp>
    <prop>/autopilot/internal/elevator-trim-gain</prop>
    <value>0.02</value>
  </Kp>
  <beta>1.0</beta>
  <alpha>0.1</alpha>
  <gamma>0.0</gamma>
  <Ti>2.0</Ti>
  <Td>0.2</Td>
  <u_min>-1.0</u_min>
  <u_max>1.0</u_max>
</config>
</pid-controller>

```

IMPORTANT NOTE: The `<Kp>` tag in PID controllers has been revised to operate in the same way as the `<gain>` elements in filters. However, the original format of `<Kp>` will continue to function as before i.e. `<Kp>0.02</Kp>` will specify a fixed and unalterable gain factor, but a warning message will be output.

The gain type filter is similar to the reciprocal filter except that the gain is applied as a simple factor to the input.

---

#### Parameters

`<name>` The name of the filter. Give it a sensible name!

`<debug>` If this tag is set to true debugging info will be printed on the console.

`<enable>` Encloses the `<prop>` and `<value>` tags which are used to enable or disable the filter. Instead of the `<prop>` and `<value>` tags, a `<condition>` tag may be used to define a condition. Check README.conditions for more details about conditions. Defaults to enabled if unspecified.

`<type>` The type of filter. This can be exponential, double-exponential, moving-average, noise-spike, gain or reciprocal.

`<input>` The input property to be filtered. This should of course be a numerical property, filtering a text string or a boolean value does not make sense.

`<output>` The filtered value. You can make up any new property.

`<u_min>` The minimum output value from the filter. Defaults to -infinity.

`<u_max>` The maximum output value from the filter. Defaults to +infinity.

These are the tags that are applicable to all filter types. The following tags are filter specific.

`<filter-time>` This tag is only applicable for the exponential and double-exponential filter types. It controls the bandwidth of the filter. The bandwidth in Hz of the filter is:  $1/\text{filter-time}$ . So a low-pass filter with a bandwidth of 10Hz would have a filter time of  $1/10 = 0.1$

`<samples>` This tag only makes sense for the moving-average filter. It says how many past samples to average.

<max-rate-of-change> This tag is applicable for the noise-spike filter. Is says how much the value is allowed to change per second.

<gain> This, and it's enclosed <prop> and <value> tags, are only applicable to the gain and reciprocal filter types. The <prop> tag specifies a property node to hold the gain value and the <value> tag specifies an initial default value. The gain defaults to 1.0 if unspecified.

The output from the gain filter type is:  $\text{input} * \text{gain}$ .

The output from the reciprocal filter type is:  $\text{gain} / \text{input}$ .

The gain can be changed during run-time by updating the value in the property node.

## 10 Effects

### Effects

-----

Effects describe the graphical appearance of 3d objects and scenery in FlightGear. The main motivation for effects is to support OpenGL shaders and to provide different implementations for graphics hardware of varying capabilities. Effects are similar to DirectX effects files and Ogre3D material scripts.

An effect is a property list. The property list syntax is extended with new "vec3d" and "vec4d" types to support common computer graphics values. Effects are read from files with a ".eff" extension or can be created on-the-fly by FlightGear at runtime. An effect consists of a "parameters" section followed by "technique" descriptions. The "parameters" section is a tree of values that describe, abstractly, the graphical characteristics of objects that use the effect. Techniques refer to these parameters and use them to set OpenGL state or to set parameters for shader programs. The names of properties in the parameter section can be whatever the effects author chooses, although some standard parameters are set by FlightGear itself. On the other hand, the properties in the techniques section are all defined by the FlightGear.

### Techniques

-----

A technique can contain a predicate that describes the OpenGL functionality required to support the technique. The first technique with a valid predicate in the list of techniques is used to set up the graphics state of the effect. A technique with no predicate is always assumed to be valid. The predicate is written in a little expression language that supports the following primitives:

and, or, equal, less, less-equal

glversion - returns the version number of OpenGL

extension-supported - returns true if an OpenGL extension is supported

property - returns the boolean value of a property

float-property - returns the float value of a property, useful inside equal, less or less-equal nodes

shader-language - returns the version of GLSL supported, or 0 if there is none.

The proper way to test whether to enable a shader-based technique is:

```
<predicate>
  <and>
    <property>/sim/rendering/shader-effects</property>
    <less-equal>
      <value type="float">1.0</value>
      <shader-language/>
    </less-equal>
  </and>
</predicate>
```

There is also a property set by the user to indicate what is the level of quality desired. This level of quality can be checked in the predicate like this :

```
<predicate>
  <and>
    <property>/sim/rendering/shader-effects</property>
  <less-equal>
    <value type="float">2.0</value>
    <float-property>/sim/rendering/quality-level</float-property>
  </less-equal>
</predicate>
```



```

</less-equal>
<!-- other predicate conditions -->
</and>
</predicate>

```

The range of `/sim/rendering/quality-level` is [0..5]  
 \* 2.0 is the threshold for relief mapping effects,  
 \* 4.0 is the threshold for geometry shader usage.

A technique can consist of several passes. A pass is basically an Open Scene Graph StateSet. Ultimately all OpenGL and OSG modes and state attributes will be accessible in techniques. State attributes -- that is, technique properties that have children and are not just boolean modes -- have an `<active>` parameter which enables or disables the attribute. In this way a technique can declare parameters it needs, but not enable the attribute at all if it is not needed; the decision can be based on a parameter in the parameters section of the effect. For example, effects that support transparent and opaque geometry could have as part of a technique:

```

<blend>
<active><use>blend/active</use></active>
<source>src-alpha</source>
<destination>one-minus-src-alpha</destination>
</blend>

```

So if the `blend/active` parameter is true blending will be activated using the usual blending equation; otherwise blending is disabled.

#### Values of Technique Attributes

-----

Values are assigned to technique properties in several ways:

- \* They can appear directly in the techniques section as a constant. For example:

```

<uniform>
  <name>ColorsTex</name>
  <type>sampler-1d</type>
  <value type="int">2</value>
</uniform>

```

- \* The name of a property in the parameters section can be referenced using a "use" clause. For example, in the technique section:

```

<material>
  <ambient><use>material/ambient</use></ambient>
</material>

```

Then, in the parameters section of the effect:

```

<parameters>
  <material>
    <ambient type="vec4d">0.2 0.2 0.2 1.0</ambient>
  </material>
</parameters>

```

It's worth pointing out that the "material" property in a technique specifies part of OpenGL's state, whereas "material" in the parameters section is just a name, part of a hierarchical namespace.

- \* A property in the parameters section doesn't need to contain a constant value; it can also contain a "use" property. Here the value of the use clause is the name of a node in an external property tree which will be used as the source of a

value. If the name begins with '/', the node is in FlightGear's global property tree; otherwise, it is in a local property tree, usually belonging to a model [NOT IMPLEMENTED YET]. For example:

```
<parameters>
  <chrome-light><use>/rendering/scene/chrome-light</use></chrome-light>
</parameters>
```

The type is determined by what is expected by the technique attribute that will ultimately receive the value. [There is no way to get vector values out of the main property system yet; this will be fixed shortly.] Values that are declared this way are dynamically updated if the property node changes.

## OpenGL Attributes

-----

The following attributes are currently implemented in techniques:

alpha-test - children: active, comparison, reference

Valid values for comparison:

never, less, equal, lequal, greater, notequal, gequal,  
always

alpha-to-coverage - true, false

blend - children: active, source, destination, source-rgb,  
source-alpha, destination-rgb, destination-alpha

Each operand can have the following values:

dst-alpha, dst-color, one, one-minus-dst-alpha,  
one-minus-dst-color, one-minus-src-alpha,  
one-minus-src-color, src-alpha, src-alpha-saturate,  
src-color, constant-color, one-minus-constant-color,  
constant-alpha, one-minus-constant-alpha, zero

cull-face - front, back, front-back

lighting - true, false

material - children: active, ambient, ambient-front, ambient-back, diffuse,  
diffuse-front, diffuse-back, specular, specular-front,  
specular-back, emissive, emissive-front, emissive-back, shininess,  
shininess-front, shininess-back, color-mode

polygon-mode - children: front, back

Valid values:

fill, line, point

program

vertex-shader

geometry-shader

fragment-shader

attribute

geometry-vertices-out - integer, max number of vertices emitted by geometry  
shader

geometry-input-type - points, lines, lines-adjacency, triangles,  
triangles-adjacency

geometry-output-type - points, line-strip, triangle-strip

render-bin - (OSG) children: bin-number, bin-name

rendering-hint - (OSG) opaque, transparent

shade-model - flat, smooth

texture-unit - has several child properties:

- unit - The number of an OpenGL texture unit
- point-sprite - true, false - Whether this should be rendered as a point-sprite
- type - This is either an OpenGL texture type or the name of a builtin texture. Currently supported OpenGL types are 1d, 2d, 3d which have the following common parameters:
  - image (file name)
  - filter - nearest, linear, [nearest|linear]-mipmap-[nearest|linear]
  - mag-filter - nearest, linear, [nearest|linear]-mipmap-[nearest|linear]
  - wrap-s - clamp, clamp-to-border, clamp-to-edge, mirror, repeat
  - wrap-t - clamp, clamp-to-border, clamp-to-edge, mirror, repeat
  - wrap-r - clamp, clamp-to-border, clamp-to-edge, mirror, repeat
  - mipmap-control - control the mipmap on a per-channel basis. Children:
    - function-r - auto, average, sum, product, min, max
    - function-g - auto, average, sum, product, min, max
    - function-b - auto, average, sum, product, min, max
    - function-a - auto, average, sum, product, min, max

The following built-in types are supported:

- white - 1 pixel white texture
- noise - a 3d noise texture. (size parameter defines size of texture)
- light-sprite - a procedurally generated sprite suitable for point lights
- cubemap - build a cube-map. Children:
  - images - build from 6 images. Children: [positive|negative]-[x|y|z]
  - image - build from a single cross-image

environment

- mode - add, blend, decal, modulate, replace
- color

texenv-combine

- combine-[rgb|alpha] - replace, modulate, add, add-signed, interpolate, subtract, dot3-rgb, dot3-rgba
- source[0|1|2]-[rgb|alpha] - constant, primary\_color, previous, texture, texture[0-7]
- operand[0|1|2]-[rgb|alpha] -src-color, one-minus-src-color, src-alpha, one-minus-src-alpha
- scale-[rgb|alpha]
- constant-color

texgen

- mode - object-linear, eye-linear, sphere-map, normal-map, reflection-map
- planes - s, t, r, q

uniform

- name
- type - float, float-vec3, float-vec4, sampler-1d, sampler-2d, sampler-3d

vertex-program-two-side - true, false

vertex-program-point-size - true, false

Inheritance

-----

One feature not fully illustrated in the sample below is that effects can inherit from each other. The parent effect is listed in the "inherits-from" form. The child effect's property tree is overlaid over that of the parent. Nodes that have the same name and property index -- set by the "n=" attribute in the property tag -- are recursively merged. Leaf property nodes from the child have precedence. This means that effects that inherit from the example effect below could be very short, listing just new parameters and adding nothing to the techniques section;

alternatively, a technique could be altered or customized in a child, listing (for example) a different shader program. An example showing inheritance Effects/crop.eff, which inherits some of its values from Effects/terrain-default.eff.

FlightGear directly uses effects inheritance to assign effects to 3D models and terrain. As described below, at runtime small effects are created that contain material and texture values in a "parameters" section. These effects inherit from another effect which references those parameters in its "techniques" section. The derived effect overrides any default values that might be in the base effect's parameters section.

Generate

-----

Often shader effects need tangent vectors to work properly. These tangent vectors, usually called tangent and binormal, are computed on the CPU and given to the shader as vertex attributes. These vectors are computed on demand on the geometry using the effect if the 'generate' clause is present in the effect file. Example :

```
<generate>
  <tangent type="int">6</tangent>
  <binormal type="int">7</binormal>
  <normal type="int">8</normal>
</generate>
```

Valid subnodes of 'generate' are 'tangent', 'binormal' or 'normal'. The integer value of these subnode is the index of the attribute that will hold the value of the vec3 vector.

The generate clause is located under PropertyList in the xml file.

In order to be available for the vertex shader, these data should be bound to an attribute in the program clause, like this :

```
<program>
  <vertex-shader>my_vertex_shader</vertex-shader>
  <attribute>
    <name>my_tangent_attribute</name>
    <index>6</index>
  </attribute>
  <attribute>
    <name>my_binormal_attribute</name>
    <index>7</index>
  </attribute>
</program>
```

attribute names are whatever the shader use. The index is the one declared in the 'generate' clause. So because generate/tangent has value 6 and my\_tangent\_attribute has index 6, my\_tangent\_attribute holds the tangent value for the vertex.

Default Effects in Terrain Materials and Models

-----

Effects for terrain work in this way: for each material type in materials.xml an effect is created that inherits from a single default terrain effect, Effects/terrain-default.eff. The parameters section of the effect is filled in using the ambient, diffuse, specular, emissive, shininess, and transparent fields of the material. The parameters image, filter, wrap-s, and wrap-t are also initialized from

the material xml. Seperate effects are created for each texture variant of a material.

Model effects are created by walking the OpenSceneGraph scene graph for a model and replacing nodes (osg::Geode) that have state sets with node that uses an effect instead. Again, a small effect is created with parameters extracted from OSG objects; this effect inherits, by default, from Effects/model-default.eff. A larger set of parameters is created for model effects than for terrain because there is more variation possible from the OSG model loaders than from the terrain system. The parameters created are:

- \* material active, ambient, diffuse, specular, emissive, shininess, color mode
- \* blend active, source, destination
- \* shade-model
- \* cull-face
- \* rendering-hint
- \* texture type, image, filter, wrap-s, wrap-t

#### Specifying Custom Effects

-----

You can specify the effects that will be used by FlightGear as the base effect when it creates terrain and model effects.

In the terrain materials.xml, an "effect" property specifies the name of the model to use.

In model .xml files, A richer syntax is supported. [TO BE DETERMINED]

Material animations will be implemented by creating a new effect that inherits from one in a model, overriding the parameters that will be animated.

#### Examples

-----

The Effects directory contains the effects definitions; look there for examples. Effects/crop.eff is a good example of a complex effect.

#### Application

-----

To apply an effect to a model or part of a model use:

```
<effect>
  <inherits-from>Effects/light-cone</inherits-from>
  <object-name>Cone</object-name>
</effect>
```

where <inherits-from> </inherits-from> contains the path to the effect you want to apply. The effect does not need the file extension.

NOTE:

Chrome, although now implemented as an effect, still retains the old method of application:

```
<animation>
  <type>shader</type>
  <shader>chrome</shader>
  <texture>glass_shader.png</texture>
```

```

    <object-name>windscreen</object-name>
  </animation>

```

in order to maintain backward compatibility.

## Model Hierarchy

-----

There are a large number of techniques used by the models, with complex inheritance. Here is a handy list of the techniques, what they are for, and where the base technique is defined

### Non-Compositor

| # Where Defined               | Summary                    |
|-------------------------------|----------------------------|
| 4 model-combined.xml          | ALS, quality>0, model>0    |
| 5 model-defaults.xml          | Base ALS                   |
| 7 model-combined-deferred.xml | Rembrandt, model>0         |
| 9 model-combined.xml          | quality>0, model>0         |
| 10 model-defaults.xml         | Base Rembrandt             |
| 11 model-defaults.xml         | Generic shaders, quality>0 |
| 13 model-defaults.xml         | Fallback - no predicate    |

### Compositor

| # Where Defined      | Summary                 |
|----------------------|-------------------------|
| 4 model-combined.xml | quality>0, model>0      |
| 7 model-combined.xml | ALS, quality>0, model>0 |
| 8 model-default.xml  | generic>0, quality>0    |
| 9 model-default.xml  | Fallback - no predicate |
| 19 model-default.xml | ALS, basic              |

## Scenery Hierarchy

-----

### Compositor

| # Where defined        | Summary                       |
|------------------------|-------------------------------|
| 8 terrain-default.xml  | quality>0, generic>0          |
| 9 terrain-default.xml  | Fallback - no predicate       |
| 17 terrain-default.xml | ALS, landmass=6, transition=6 |
| 18 terrain-default.xml | ALS, landmass>3, transition>2 |
| 19 terrain-default.xml | ALS, basic                    |

## 11 Electrical

Specifying and Configuring and Aircraft Electrical System

Written by Curtis L. Olson <curt@flightgear.org>

February 3, 2003 - Initial revision.

Introduction

The FlightGear electrical system model is an approximation. We don't model down to the level of individual electrons, but we do try to model a rich enough subset of components so that a realistic (from the pilot's perspective) electrical system may be implemented. We try to model enough of the general flow so that typical electrical system failures can be implemented and so that the pilot can practice realistic troubleshooting techniques and learn the basic structure and relationships of the real aircraft electrical system.

An electrical system can be built from 4 major components: suppliers, buses, outputs, and connectors. Suppliers are things like batteries and generators. Buses collect input from multiple suppliers and feed multiple outputs. Outputs are not strictly necessary, but are included so we can name generic output types and provide a consistent naming scheme to other FlightGear subsystems. Finally connectors connect a supplier to a bus, or a bus to an output, and optionally can specify a switch property (either a physical switch or a circuit breaker.)

At run time, the structure specified in the electrical system config file is parsed and a directional graph (in the computer science sense) is built. Each frame, the current is propagated through the system, starting at the suppliers, flowing through the buses, and finally to the outputs. The system follows the path of connectors laid out in the config file and honors the state of any connector switch.

Suppliers

A supplier entry could look like the following:

```
<supplier>
  <name>Battery 1</name>
  <prop>/systems/electrical/suppliers/battery[0]</prop>
  <kind>battery</kind>
  <volts>24</volts>
  <amps>60</amps>    <!-- WAG -->
</supplier>
```

<name> can be anything you choose to call this entry.

<prop> is the name of a property that will be updated with the state of this supplier.

<kind> can be "battery", "alternator", or "external".

<volts> specifies the volts of the source

<amps> specifies the amps of the source

Currently <volts> and <amps> are not really modeled in detail. This is more of a place holder for the future.

For alternators, you must additionally specify:

```
<rpm-source>/engines/engine[0]/rpm</rpm-source>
```

The value of the rpm source determines if the generator is able to produce power or not.

## Buses

=====

A bus entry could look like the following:

```
<bus>
  <name>Essential/Cross Feed Bus</name>
  <prop>/systems/electrical/outputs/bus-essential</prop>
  <prop>/systems/electrical/outputs/annunciators</prop>
  <prop>/systems/electrical/outputs/master-switch</prop>
</bus>
```

<name> is whatever you choose to call this bus

You can have an arbitrary number of <prop> entries. Each entry is the name of a property that will be updated with the value of the current at that bus. This allows you to wire devices directly to the bus but does not allow you to insert a switch or circuit breaker in between. See "Outputs" and "Connectors" if you want to do that.

## Outputs

=====

An output entry could look like the following:

```
<output>
  <name>Starter 1 Power</name>
  <prop>/systems/electrical/outputs/starter[0]</prop>
</output>
```

An output isn't entirely unlike a bus, but it's nice conceptually to have a separate entity type. This enables us to specify a common set of output property names so that other subsystems can automatically work with any electrical system that follows the same conventions. An output lives on the other side of a switch, so this is how you can wire in cockpit switches to model things like fuel pump power, avionics master switch, or any other switch on the panel.

<name> is whatever you choose to call this bus

You can have an arbitrary number of <prop> entries. Each entry is the name of a property that will be updated with the value of the current at that bus. This allows you to wire devices directly to the bus but does not allow you to insert a switch or circuit breaker in between. See "Outputs" and "Connectors" if you want to do that.

Other FlightGear subsystems can monitor the property name associated with the various outputs to decide how to render an instrument, whether to run the fuel pump, whether to spin a gyro, or any other subsystem that cares about electrical power.

## Connectors

=====



An connector entry could look like the following:

```
<connector>
  <input>Alternator 1</input>
  <output>Virtual Bus 1</output>
  <switch>/controls/switches/master-alt</switch>
  <initial-state>off</initial-state>  <!-- optional tag -->
</connector>
```

A connector specifies and input, and output, and any number of switches that are wired in series. In other words, all switches need to be true/on in order for current to get from the input to the output of the connector.

<input> specifies the <name> of the input. Typically you would specify a "supplier" or a "bus".

<output> specifies the <name> of the output. Typically you would specify a bus or an output.

You can have an arbitrary number of <switch> entries. The switches are wired in series so all of them need to be on (i.e. true) in order for current to pass to the output.

Note: by default the system forces any listed switches to be true. The assumption is that not every aircraft or cockpit may impliment every available switch, so rather than having systems be switched off, with no way to turn them on, we default to switched on.

This is a problem however with the starter switch which we want to be initialized to "off". To solve this problem you can specify <initial-state>off</initial-state> or <initial-state>on</initial-state> Switches default to on, so you really only need to specify this tag if you want the connector's switch to default to off.

Summary  
=====

The electrical system has a lot of power and flexibility to model a variety of electrical systems. However, it is not yet perfect or finished. One major weakness is that it doesn't yet model degraded battery or generator power, and it doesn't model the "charge" of the batteries in case of a generator failure.

## 12 Embedded-resources

```
 -*- coding: utf-8; fill-column: 72; -*-
```

The Embedded Resources System  
=====

This document gives an overview of FlightGear's embedded resources system and related classes. For specific information on the C++ functions, the reference documentation is in the corresponding header files.

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-----

1. The CharArrayStream and ZlibStream classes
2. The "embedded resources" system
3. About the XML resource declaration files
4. The EmbeddedResourceProxy class

Introduction  
-----

The embedded resources system allows FlightGear to use data from files without relying on FG\_ROOT to be set. This can be used, for instance, to grab the contents of XML files at FG build time, from any repository[1], and use said contents in the C++ code. The term "embedded" is used to avoid confusion with the ResourceProvider and ResourceManager classes provided by SimGear, which have nothing to do with the system described here.

The embedded resources system relies on classes present in `simgear/io/iostreams/{zlibstream.cxx,CharArrayStream.cxx}`, which were implemented as a way to address a concern that embedding a few XML files in the fgfs binary could use precious memory. The resource compiler (`fgrcc`) compresses resources before writing them in C++ form---except for some extensions, and it's configurable on a per-resource basis anyway. Then, the `EmbeddedResourceManager` instance, which lives in the fgfs process, can decompress them on-the-fly, incrementally, transparently. So, there is really no reason to worry about memory consumption, even for several dozens of XML files.

`fgrcc` is the resource compiler: it turns arbitrary files into C++ code the `EmbeddedResourceManager` can make use of, in order to "serve" the files' contents at runtime. It is named this way, because it fulfills the same role as Qt's `rcc` tool. It supports a thin superset of the XML-based format used by `rcc` for declaring resources[2][3].  
'`fgrcc --help`' gives a lot of info.

### 1) The CharArrayStream and ZlibStream classes

~~~~~

The `CharArrayStream*` files in `simgear/io/iostreams/` implement `CharArrayStreambuf` and related `IOStreams` classes for working with char arrays, namely:

- | | | |
|-------------------------------------|---|---------------------|
| - <code>CharArrayStreambuf</code> | subclass of <code>std::streambuf</code> | stream buffer |
| - <code>ROCharArrayStreambuf</code> | subclass of <code>CharArrayStreambuf</code> | stream buffer |
| - <code>CharArrayIStream</code> | subclass of <code>std::istream</code> | input stream |
| - <code>CharArrayOStream</code> | subclass of <code>std::ostream</code> | output stream |
| - <code>CharArrayIOStream</code> | subclass of <code>std::iostream</code> | input/output stream |

(in the 'simgear' namespace, of course)

CharArrayStreambuf is a stream buffer class allowing to read from, and write to char arrays (std::strstream has been deprecated since C++98). Contrary to std::strstream, this class does no dynamic allocation: it is very simple, strictly staying for both reads and writes within the bounds of the buffer specified in its constructor. Contrary to std::stringstream, CharArrayStreambuf allows one to work on an array of char (that could be static data, on the stack, whatever) without having to make a whole copy of it.

ROCharArrayStreambuf is a read-only subclass of CharArrayStreambuf (useful for const-correctness). CharArrayIStream, CharArrayOStream and CharArrayIOStream are very simple convenience stream classes using either CharArrayStreambuf or ROCharArrayStreambuf as their associated stream buffer class.

While these classes can be of general-purpose usefulness, the particular reason they have been written for is to make the embedded resources system clean and memory-friendly. Concretely, this system supports both compressed and uncompressed resources, all of which can be read from their respective static arrays like this (think pipelines):

```
static char array
(uncompressed   ----->      data available via an std::istream
 resource)      CharArrayIStream    or std::streambuf interface
                or ROCharArrayStreambuf

static char array
(compressed     -----> compressed data ----->      ditto
 resource)      CharArrayIStream      ZlibDecompressorIStream
                or ZlibDecompressorIStreambuf
```

where ditto = uncompressed data available via an std::istream or
std::streambuf interface

So, whether the resource data stored in static arrays by fgrcc is compressed or not, end-user code can read it in uncompressed form using an std::istream or std::streambuf interface, which means the resource never needs to be copied in memory a second time. This is particularly interesting with compressed resources, because:

- 1) The in-memory static data is much smaller in general than the uncompressed contents, and it's the only one we really have to âpayâ for if one uses these stream-based interfaces.
- 2) The data is transparently decompressed on-demand as the end-user code reads from the ZlibDecompressorIStream or ZlibDecompressorIStreambuf instance.

In other words, these CharArrayStream classes complement the ones in zlibstream.cxx and make it easy to implement all kinds of pipelines to incrementally read or write, and possibly on-the-fly compress or decompress data from or to in-memory buffers (cf. writeCompressedDataToBuffer() in simgear/simgear/embedded_resources/embedded_resources_test.cxx, or ResourceCodeGenerator::writeEncodedResourceContents() in flightgear/src/EmbeddedResources/fgrcc.cxx for examples).

Since all of these provide standard IOStreams interfaces, they can be easily plugged into existing code. For instance, readXML() in simgear/simgear/xml/easyxml.cxx and readProperties() in

simgear/props/props_io.cxx can incrementally read and parse data from an `std::istream` instance, and thus are able to directly read from a resource containing the compressed version of an XML file.

This incremental stuff is of course really interesting with large resources... which probably won't be used in FlightGear, in order not to waste RAM[4][5]. The `EmbeddedResourceManager` also has a `getString()` method to simply get an `std::string` when you don't care about the fact that this operation, by `std::string` design, will necessarily make a copy of the whole resource contents (in uncompressed form in the case of a compressed resource). This `getString()` method should be convenient and quite acceptable for reasonably-sized resources.

Finally, all of these classes---`CharArray*Stream*`, the classes in `zlibstream.cxx`, the `EmbeddedResourceManager` and related classes---can handle text and binary data in exactly the same way (`std::string` doesn't care, and neither do the other classes).

2) The `embedded resources` system

~~~~~

The embedded resources system works this way:

- (1) The `fgrcc` resource compiler reads an XML file which has almost the same syntax[2] as Qt's `.qrc` files[3] and writes a `.cxx` file containing:
  - static char arrays initialized with resource contents (possibly compressed, this is automatic unless explicitly specified in the XML file);
  - a function definition containing calls to `EmbeddedResourceManager::addResource()` that register each of these resources with the `EmbeddedResourceManager` instance.

If you pass the `--output-header-file` option to `fgrcc`, it also writes a header file that goes with the generated `.cxx` file. For other options, see the output of `'fgrcc --help'`.

It is quite possible to call `fgrcc` several times, each time with a different (XML input file, `.cxx/.hxx` output files) tuple: for instance, one call for resources present in the FlightGear repo, and possibly another call for resources in `FGData`. The point of this is that paths in the XML input file should be relative to avoid being system-dependent, and `fgrcc` accepts a `--root` option to indicate what you want them to be relative to, in order to let it find the real files. Thus, on a first invocation of `fgrcc`, one can make `--root` point to a path to the FlightGear repository when building, and on the second call use it to indicate a path to the `FGData` repository. Other variations are possible, of course.

Notes:

- 1) The example given here with `FGData` would *\*not\** freeze the `FGData` location at FG compile time; this is only to allow files from `FGData` to be turned into generated `.cxx` files inside the FG source tree, that will make their contents available as embedded resources at runtime.
- 2) At the time of this writing, resources from the FlightGear repository are compiled at build time, and resources from the `FGData` repository are compiled offline using the `'rebuild-fgdata-embedded-resources'` script[6] (a convenience wrapper for `fgrcc`), before being committed to the

FlightGear repository.

- (2) SimGear contains an `EmbeddedResourceManager` class with, among others, `createInstance()` and `instance()` methods similar to the ones of `NavDataCache`. See [7] for the corresponding code.

FlightGear creates an `EmbeddedResourceManager` instance at startup and calls the various init functions generated by `fgrcc`, each of which registers the resources present in its containing `.cxx` file (using `EmbeddedResourceManager::addResource()`).

End-user FG code can then use `EmbeddedResourceManager` methods such as `getResource()`, `getString()`, `getStreambuf()` and `getIStream()` to access resource contents:

- `getResource()` returns an `std::shared_ptr<const AbstractEmbeddedResource>`
- `getString()` returns an `std::string`
- `getStreambuf()` returns an `std::unique_ptr<std::streambuf>`
- `getIStream()` returns an `std::unique_ptr<std::istream>`

`AbstractEmbeddedResource` is an abstract base class that you can think of as a resource descriptor: it points to (not contains!) the resource data (which is normally of static storage class), and contains + gives access to metadata such as the compression type and resource size (compressed and uncompressed).

`AbstractEmbeddedResource` currently has two derived concrete classes: `RawEmbeddedResource` for resources stored as-is (uncompressed) and `ZlibEmbeddedResource` for resources compressed by `fgrcc`. It's quite easy to add new subclasses if wanted, e.g. for LZMA compression or other things.

Resource fetching requires two things:

- an `std::string` key (`fgrcc` manipulates them with `SGPath`, but the `EmbeddedResourceManager` code in `SimGear` is so far completely agnostic of the kind of data stored in keys; this could be changed, though, if we wanted for example to be able to query at runtime all available resources in a given virtual directory);
- a `locale` name, similar to what FlightGear's XML translation files and `FGLocale` use. We used double quotes here, because `fgrcc` and the `EmbeddedResourceManager` expect `locale` names to be of one of these forms:
  - \* empty string: default locale, typically but not necessarily English (it is `engineering English` in FlightGear, i.e., English written by programmers in the code, before translators possibly fix it up :)
  - \* `en`, `fr`, `de`, `es`, `it`...
  - \* `en_GB`, `en_US`, `fr_FR`, `fr_CA`, `de_DE`, `de_CH`, `it_IT`...

There is no encoding part, contrary to POSIX locales, hence the use of double quotes around the term `locale` in this context.

The `FGLocale::getPreferredLanguage()` method returns the preferred `locale` in the form described above, according to user choice (from `fgfs`' `--language` option) and/or settings (system locale). This allows FG to tell the `EmbeddedResourceManager` the preferred `locale` for resource fetching (same syntax as in Qt's `rcc` tool for declaration in the XML file, using the `'lang'` attribute on `'qresource'` elements).

[ Regarding the default locale, the way things are currently set up, I would use no 'lang' attribute for resources suitable for English in the XML input file for fgrcc, except when a country-specific variant is desired (en\_GB, en\_US, en\_AU...). In such a case, there should also be a generic variant with no 'lang' attribute declared for the same resource virtual path. This matches what I did for FGLocale::getPreferredLanguage(), that maps unset locales and locales such as C and C.UTF-8 to the default locale for the EmbeddedResourceManager, which is the empty string. This is a matter of policy, of course, and could be changed if desired. ]

The EmbeddedResourceManager class has getLocale() and selectLocale() methods to manage the \_selected locale\_. Each resource-fetching method of this class (getResourceOrNullPtr(), getResource(), getString(), getStreambuf() and getIStream()) has two overloads:

- one taking only a virtual path (the key mentioned above);
- one taking a virtual path and a `locale` name.

(we'll write `locale` without enclosing double-quotes from now on, otherwise it gets too painful to read; but we're *not* talking about POSIX-style locales ending with an encoding part)

The first kind of overload uses the selected locale to look up the resource, whereas the second kind uses the explicitly specified locale. Then resource lookup behaves as one could expect. For instance, assuming a resource is looked up for in the "fr\_FR" locale, then the EmbeddedResourceManager tries in this order:

- "fr\_FR";
- if no resource has been registered for "fr\_FR" with the provided virtual path, it then tries with the "fr" locale;
- if this is also unsuccessful, it finally tries with the default locale: "";
- if this third attempt fails, the resource-fetching method throws an `sg_exception`, except for `getResourceOrNullPtr()`, which returns a null `std::shared_ptr<const AbstractEmbeddedResource>` instead.

To see how this is used, you can look at `simgear/simgear/embedded_resources/embedded_resources_test.cxx`. The only difference with real use is that in this file, resource contents and registering calls with the EmbeddedResourceManager have been written manually instead of by fgrcc. Apart from `embedded_resources_test.cxx`, here are two examples of client usage of the EmbeddedResourceManager:

(a) With `EmbeddedResourceManager::getString()`:

```
#include <simgear/embedded_resources/EmbeddedResourceManager.hxx>
#include <simgear/debug/logstream.hxx>

[...]

const auto& resMgr = simgear::EmbeddedResourceManager::instance();
SG_LOG(SG_GENERAL, SG_INFO,
    "Resource contents: '" <<
    resMgr->getString("/virtual/path/to/resource") << "'");
```

(b) With `EmbeddedResourceManager::getIStream()`:

```
#include <cstdint> // std::size_t
#include <simgear/io/iostreams/sgstream.hxx>
```

```
#include <simgear/embedded_resources/EmbeddedResourceManager.hxx>

[...]

sg_ofstream outFile(SGPath("/tmp/whatever"));
if (!outFile) {
    <handle open error>
}

const auto& resMgr = simgear::EmbeddedResourceManager::instance();
auto resStream = resMgr->getIStream("/virtual/path/to/resource");
// One possible way of handling errors from resStream[8]:
// resStream->exceptions(std::ios_base::badbit);

constexpr std::size_t bufSize = 4096;
std::unique_ptr<char[]> buf(new char[bufSize]); // intermediate buffer

do {
    resStream->read(buf.get(), bufSize);
    outFile.write(buf.get(), resStream->gcount());
} while (*resStream && outFile); // resStream *points* to an std::istream

<handle possible errors that might have caused to loop to stop
prematurely>
```

### 3) About the XML resource declaration files

~~~~~

You may want to read the output of 'fgrcc --help', which explains a few things, in particular how to write an XML resource declaration file that fgrcc can use. At the time of this writing, such files are already present as flightgear/src/EmbeddedResources/FlightGear-resources.xml and flightgear/src/EmbeddedResources/FGData-resources.xml in the FlightGear repository. In case you need resources from elsewhere, it's easy to add other XML resource declaration files:

- 1) If you want the .cxx/.hxx resource files to be automatically generated as part of the FlightGear build:

Copy and adapt the add_custom_command() call in flightgear/src/Main/CMakeLists.txt[9] that invokes fgrcc on flightgear/src/EmbeddedResources/FlightGear-resources.xml.

- 2) In flightgear/src/Main/CMakeLists.txt, add paths for your new fgrcc-generated .cxx and .hxx files to the SOURCES and HEADERS CMake variables for the 'fgfs' target.

- 3) Assuming you passed for instance --init-func-name=initFoobarEmbeddedResources in step 1, add a call to initFoobarEmbeddedResources() after this code in fgMainInit() (flightgear/src/Main/main.cxx):

```
simgear::EmbeddedResourceManager::createInstance();
initFlightGearEmbeddedResources();
```

4) The EmbeddedResourceProxy class

~~~~~

SimGear contains an EmbeddedResourceProxy class that allows one to access real files or embedded resources in a unified way. When using it, one can switch from one data source to the other with minimal code

changes, possibly even at runtime (in which case there is obviously no code change at all).

Sample usage (from FlightGear):

```
simgear::EmbeddedResourceProxy proxy(globals->get_fg_root(), "/FGData");
proxy.setUseEmbeddedResources(false); // can also be set via the constructor

std::string s = proxy.getString("/some/path");
std::unique_ptr<std::istream> streamp = proxy.getIStream("/some/path");
```

This example would retrieve contents from the real file \$FG\_ROOT/some/path. If true had been passed in the proxy.setUseEmbeddedResources() call, it would instead have used the default-locale version of the embedded resource whose virtual path is /FGData/some/path.

For more information about this class, see [10] and [11].

#### Footnotes =====

[1] E.g., FlightGear or FGData, as long as the path to the latter is provided to the FG build system, which is currently possible but not required (passing '-D FG\_DATA\_DIR:PATH=...' to CMake when configuring the FlightGear build).

[2] The differences with the QRC format[3] are explained in the output of 'fgrcc --help'. Here is the relevant excerpt:

```
,-----
| 1. The <!DOCTYPE RCC> declaration at the beginning should be omitted (or
|    replaced with <!DOCTYPE FGRCC>, however such a DTD currently doesn't
|    exist). I suggest to add an XML declaration instead, for instance:
|
|    <?xml version="1.0" encoding="UTF-8"?>
|
| 2. <RCC> and </RCC> must be replaced with <FGRCC> and </FGRCC>,
|    respectively.
|
| 3. The FGRCC format supports a 'compression' attribute for each 'file'
|    element. At the time of this writing, the allowed values for this
|    attribute are 'none', 'zlib' and 'auto'. When set to a value that is
|    not 'auto', this attribute of course bypasses the algorithm for
|    determining whether and how to compress a given resource (algorithm
|    which relies on the file extension).
|
| 4. Resource paths (paths to the real files, not virtual paths) are
|    interpreted relatively to the directory specified with the --root
|    option. If this option is not passed to 'fgrcc', then the default root
|    directory is the one containing INFILE, which matches the behavior of
|    Qt's 'rcc' tool.
'-----
```

[3] <http://doc.qt.io/qt-5/resources.html>

[4] The main reason why I wrote the classes in simgear/simgear/io/iostreams/{CharArrayStream,zlibstream}.cxx is thus not to maximize memory-efficiency with very large resources; rather, it is to make the implementation of the following parts simple, clean and modular:

- the resource compiler (fgrcc);



- the `EmbeddedResourceManager`.

[5] The `EmbeddedResourceManager` architecture would make it quite easy to also support runtime loading of resources from files (a thing the Qt resource system supports), but it is not very clear how interesting this would be, compared to having the files loaded from `$FG_ROOT`. Well, maybe for large files [apt.dat.gz & Co] that we would want to load but not see in the FGData repository at all. But then there would be the requirement, of course, that `âsomethingâ` puts the files in a clearly-defined, platform-dependent location known to the `EmbeddedResourceManager`.

[6] <https://sourceforge.net/p/flightgear/fgmeta/ci/next/tree/python3-flightgear/rebuild-fgdata-embedde>

[7] [https://sourceforge.net/p/flightgear/simgear/ci/next/tree/simgear/embedded\\_resources/](https://sourceforge.net/p/flightgear/simgear/ci/next/tree/simgear/embedded_resources/)

[8] We know that in some buggy C++ implementations, the `std::ios_base::failure` exception can't be caught, at least not under its name, due to some ABI compatibility mess:

[https://gcc.gnu.org/bugzilla/show\\_bug.cgi?id=66145](https://gcc.gnu.org/bugzilla/show_bug.cgi?id=66145)

However, it stills causes the program to abort, and since this error handling technique makes for much more readable and less error-prone code, I think it's still a good way to handle `IOStreams` errors even now, unless you really need to *\*catch\** the `std::ios_base::failure` exception.

[9] `flightgear/CMakeModules/GenerateFlightgearResources.cmake` in my 'i18n-and-init-work-v2' branch (not merged into 'next' at the time of this writing).

[10] [https://sourceforge.net/p/flightgear/simgear/ci/next/tree/simgear/embedded\\_resources/EmbeddedResou](https://sourceforge.net/p/flightgear/simgear/ci/next/tree/simgear/embedded_resources/EmbeddedResou)

[11] [https://sourceforge.net/p/flightgear/simgear/ci/next/tree/simgear/embedded\\_resources/embedded\\_reso](https://sourceforge.net/p/flightgear/simgear/ci/next/tree/simgear/embedded_resources/embedded_reso)

## 13 Expressions

Expressions (or SGExpressions) are a feature of the SimGear library and provide a nice way of implementing complex math formulas using XML syntax. They are supported in many systems within the FlightGear code.

Caution: Expressions do not check if your math creates floating point exceptions (like division by zero conditions, taking the square root of a negative number, etc.). This can cause undefined behavior and may result in NaNs or even Cascading NaNs. Usage

Expressions are supported in

- \* Autopilot configuration files
- \* Particle system configuration files
- \* Animations (translate, rotate, scale, range, blend)
- \* The shader technique

Sample Expressions

This is a sample expression for the equation  $c = \sqrt{a^2 + b^2}$ .

Children/arguments are parsed in the order they appear in in the file (or the order in which they are set via property methods).

```
<expression>
  <sqrt>
    <sum>
      <product>
        <property>/value/a</property>
        <property>/value/a</property>
      </product>
      <pow>
        <property>/value/b</property>
        <value>2</value>
      </pow>
    </sum>
  </sqrt>
</expression>
```

Supported elements

NOTE: #c in the table below is the number of child nodes required.

| Function           | #c | Notes                        |
|--------------------|----|------------------------------|
| <abs> <fabs>       | 1  |                              |
| <acos>             | 1  |                              |
| <asin>             | 1  |                              |
| <atan2>            | 2  |                              |
| <atan>             | 1  |                              |
| <ceil>             | 1  |                              |
| <clip>             | 3  | clipMin, clipMax, expression |
| <cos>              | 1  |                              |
| <cosh>             | 1  |                              |
| <deg2rad>          | 1  |                              |
| <difference> <dif> | 1+ |                              |
| <div>              | 2  |                              |
| <exp>              | 1  |                              |
| <floor>            | 1  |                              |
| <log10>            | 1  |                              |
| <log>              | 1  |                              |



## 14 Fgjs

fgjs -- a small program for creating a basic FlightGear joystick configuration

fgjs requires plib to be installed on your system. If you've successfully installed and built FlightGear then you should be all set

### Build instructions

At this point, fgjs has only been built and tested under Linux, so the makefile is a simple one. cd into the directory in which the fgjs source resides and type 'make' and, if you are lucky, all will go well. You can e-mail me (apeden@earthlink.net) any changes needed to make it work on other systems. It's quite possible that this program will become part of the regular FlightGear package so

### Running

Set up your joystick and make sure it works with js\_demo from the FlightGear distribution. Upon executing fgjs, it will prompt you to move the control you wish to use for elevator, ailerons, etc. Note that when being prompted for an analog control, you can skip the current one by pressing any button and vice-versa when being prompted for a button. You may want to do this if for, as an example, rudder if you have only one joystick or your joystick doesn't have as many analog axes as FlightGear supports.

Once you've run with this configuration, you may wish to tune the dead-band a bit (see fgsrc.js) as the default, 0.02, may be too narrow for your particular hardware/taste.

And last, but not least, this thing needs a GUI!!!! Hopefully, the joystick handling code and interface code are separate enough that using that a GUI version could be built using this source as a starting point.

## 15 Flightrecorder

FlightGear Flight Recorder Mini-HOWTO

Thorsten Brehm

Started in August 2011

Last revised: 2011-09-26

FlightGear provides a customizable flight recorder capable of capturing any selection of properties described via XML configuration files. The recorder is currently used for the replay system.

### Feature Brief

- \* Generic recording system, adaptable to any aircraft/data, provided that data is accessible via the property tree. No hard-coded selections or assumptions on properties to be recorded.
- \* Configuration read from XML files or the property tree itself.
- \* Interpolation method configurable per recorded/replayed signal.
- \* Adaptable recording resolution per signal.
- \* Multiple configurations supported.

### Quick Start: Basic Configuration

To configure and adapt the flight recorder, add a `"/sim/flight-recorder"` section to your aircraft `-set.xml` file.

Example:

```
<sim>

<!-- ... -->

<flight-recorder>
  <replay-config type="int">0</replay-config>
  <config n="0"
    include="/Aircraft/Generic/flightrecorder/generic-piston-propeller-1.xml">
    <name type="string">My Aircraft's Flight Recorder</name>
    <!-- Custom properties -->
    <signal>
      <type>float</type>
      <property type="string">/controls/gear/nosegear-steering-cmd-norm</property>
      <interpolation>linear</interpolation>
    </signal>
    <!-- More custom signals here -->
  </config>
</flight-recorder>

<!-- ... -->

</sim>
```

Default type for each signal is "float". Default "interpolation" method is "linear" (for float/double). Default values may be omitted. See configuration details below.

### Generic Configuration Files

Select one of the default configuration files to specify the basic

properties to be recorded. It's not recommended to specify all properties to be recorded individually.  
The following generic files are provided:

- \* /Aircraft/Generic/flightrecorder/generic-piston-propeller-4.xml  
Matches propeller aircraft with 4 piston engines, 4 tanks, 3 retractable gear.  
It is the same configuration that was hard-coded for the replay system up to FlightGear 2.4.0. To provide backward compatibility this configuration is loaded by default, unless an aircraft provides a specific flight recorder configuration.
- \* /Aircraft/Generic/flightrecorder/generic-piston-propeller-1.xml  
Matches propeller aircraft with 1 piston engines, 2 tanks, 3 fixed gear.
- \* /Aircraft/Generic/flightrecorder/generic-turboprop-2.xml  
Matches turboprop aircraft with 2 turbines/propellers, 4 tanks, 3 retractable gear.
- \* /Aircraft/Generic/flightrecorder/generic-jet.xml  
Matches jet aircraft with 2 jet engines, 4 tanks.
- \* /Aircraft/Generic/flightrecorder/generic-glider.xml  
Matches gliders (no engines, no tanks, single fixed gear).
- \* /Aircraft/Generic/flightrecorder/generic-helicopter.xml  
Matches helicopters with main and tail rotor (tested with YASim).

If none of the generic files matches your aircraft, simply use a configuration which covers more than you need. Alternatively, copy the contents of one of these generic files to your aircraft, and adapt as needed (see below).

FDM experts are welcome to add more generic configuration files to /Aircraft/Generic/flightrecorder - such as YASim-/JSBSim-specific configurations, and configurations for other types of aircraft (balloons, airships, ...).

## Generic Components

-----  
The generic configuration files in turn include a set of generic components. If you copy the contents of a generic file to your aircraft, you can adapt the components to your needs. See examples.  
It is not recommended to copy the contents of the `_component_` files to an aircraft though (causes too much hassle and dependencies).

### Engine Selection:

- \* /Aircraft/Generic/flightrecorder/components/engine-jet.xml  
Records properties of a single jet engine.  
For multiple jet engines, use "count". Example for 4 jets:  

```
<signals include="/Aircraft/Generic/flightrecorder/components/engine-jet.xml">  
  <count>4</count>  
</signals>
```
- \* /Aircraft/Generic/flightrecorder/components/engine-piston.xml  
Records properties of a single piston engine and propeller.  
For multiple piston engines, use "count" (see "jet" example).
- \* /Aircraft/Generic/flightrecorder/components/rotor.xml  
Records properties of a single helicopter rotor (tested with YASim).  
To use this, provide the base property path to the rotor as "prefix".

Example recording the rotor below "/rotors/main":

```
<signals include="/Aircraft/Generic/flightrecorder/components/rotor.xml">
  <prefix type="string">/rotors/main</prefix>
</signals>
```

#### Gear Selection:

- \* /Aircraft/Generic/flightrecorder/components/gear-fixed.xml  
Records properties of a single non-retractable gear.  
For multiple fixed gear, use "count" (see "jet" example).
- \* /Aircraft/Generic/flightrecorder/components/gear-retractable.xml  
Records properties of a single retractable gear.  
For multiple retractable gear, use "count" (see "jet" example).

#### Tanks:

- \* /Aircraft/Generic/flightrecorder/components/tanks.xml  
Records properties of a single fuel tank.  
For multiple fuel tanks, use "count" (see "jet" example).

#### Other:

- \* /Aircraft/Generic/flightrecorder/components/surfaces.xml  
Records properties of flight control surfaces. Include this for aircraft (with wings). Not useful for helicopters, balloons, ...
- \* /Aircraft/Generic/flightrecorder/components/faults-engines.xml  
Records fault properties of a single engine. Only include this if your aircraft supports fault simulation.  
For multiple engines, use "count" (see "jet" example). If used, it should be compined with piston or jet engine.
- \* /Aircraft/Generic/flightrecorder/components/environment.xml  
Records properties of environment/weather (visibility, temperature - but not cloud position...).
- \* /Aircraft/Generic/flightrecorder/components/position.xml  
Records properties of a the aircrafts main position (latitude, longitude, velocities, ...).  
This is the most important component. Always include this.
- \* /Aircraft/Generic/flightrecorder/components/controls.xml  
Records most important flight controls (rudder, aileron, elevator, ...). Always include this.

#### Custom Properties

-----

When the generic or component files are not be sufficient to record or replay aircraft-specific effects, you can add custom properties (signals to be recorded) to the configuration.

Each signal consits of a recording type/resolution (which does not need to match the actual type in the property tree!), the path to the property and interpolation type.

Example recording some additional custom properties:

```
<sim>
  <flight-recorder>
    <config n="0"
      include="/Aircraft/Generic/flightrecorder/generic-piston-propeller-1.xml">
      <!-- Add custom properties here -->
    </config>
    <signal>
      <type>float</type>
      <property type="string">/controls/gear/nosegear-steering-cmd-norm</property>
```

```

    </signal>
    <signal>
      <type>double</type>
      <interpolation>rotational-deg</interpolation>
      <property type="string">ai/model/carrier/alpha-angle-deg</property>
    </signal>
    <signal>
      <type>bool</type>
      <property type="string">/controls/panel/custom-switch</property>
    </signal>
  </config>
</flight-recorder>
</sim>

```

## Signal Configuration

-----

Template:

```

<signal>
  <type>bool</type>
  <interpolation>angular-deg</interpolation>
  <property type="string">/controls/panel/custom-switch</property>
</signal>

```

\* type: The signal's type specifies the recording resolution - not the type of the original property. The following types are supported:

- double: 8 byte/sample
- float: 4 byte/sample (default)
- int: 4 byte/sample, integer
- int16: 2 byte/sample, integer
- int8: 1 byte/sample, integer
- bool: 1 bit/sample (yes, 1 bit. 8 bools per byte).

String type is unsupported (too expensive).

\* interpolation: Specifies how values are interpolated during replay, i.e. when replay is in slow-motion mode and more frames/second are required than recorded, or when replaying data from the medium/long term memory.

Supported methods:

- discrete: No interpolation. Default for integer/bool types.
- linear: Standard linear interpolation. Default for float/double.
- angular-rad (or angular): Angular values in radians (0-2pi).
- angular-deg: Angular values in degrees (0-360).

\* property: Path to the property to be recorded.

## Advanced Configuration

-----

- Multiple recorder configurations for a single aircraft are supported (multiple "<config n=..>" sections for n=0,1,...). Active configuration to be used for the replay system is selected via /sim/flight-recorder/replay-config (= 0,1,...). This can be useful for specific recorders for specific scenarios, which should not be used by default. For example, a specific recorder configuration could be provided which also records the position of an aircraft carrier, of other AI aircraft, ... This may also be useful for future use, i.e. to select another flight recorded configuration for a different purpose, such as for the multiplayer system.

- Flight recorder configuration can be adapted during run-time



(configuration is visible in the property browser below /sim/flight-recorder). However it is necessary to reset (reinit) the replay subsystem first - which also erases earlier recordings. It is not possible to mix recordings of different configurations on to a single "tape".

- Each configuration should be given a name. Useful for a (future) selection GUI, when multiple configurations are available.

#### Optimizing Performance

-----

- Recording properties consumes memory and also CPU time. A few additional properties don't matter much, but avoid excessive numbers. Reduce the resolution (type) of signals to the minimum necessary to save space.
- Use "bool" types where possible, they are most efficient.
- Avoid recording with "double" resolution (type "double"). Use "float" instead - even if the original property in the property tree is a "double" (almost all of them do). "float" precision is almost always sufficient for recording/replay purposes, with few exceptions (like latitude/longitude properties).
- Use int16/int8 for "small" integer values.

#### Recording/Replay Limits

-----

- All properties can be recorded, however, only writable properties can be replayed. Properties marked as read-only, or tied properties not implementing the "set" method cannot be replayed.
- Replaying a property overwrites the property's value. However, other sources may also write to the same property - such as Nasal code, autopilot rules etc. When multiple sources "fight" over a property's value then the last update "wins" - resulting in a dependency to an unknown/random sequence. Hence, during deploy, try to disable other sources writing to properties which were recorded and should be replayed.  
If the other source cannot be disabled, check if you're recording the right property. It may be better to record the input properties of the other source instead (i.e. the inputs processed by the Nasal or autopilot rule).

\_\_end\_\_

## 16 Gui

FlightGear GUI Mini-HOWTO

David Megginson

Started: 2003-01-20

Last revised: 2003-01-20

FlightGear creates its drop-down menubar and dialog boxes from XML configuration files under \$FG\_ROOT/gui. This document gives a quick explanation of how to create or modify the menubar and dialogs. The toolkit for the FlightGear GUI is PUI, which is part of plib.

All of the XML files use the standard FlightGear PropertyList format.

### MENUBAR

-----

FlightGear reads the configuration for its menubar from \$FG\_ROOT/gui/menubar.xml. The file consists of a series of top-level elements named "menu", each of which defines one of the drop-down menus, from left to right. Each menu contains a series of items, representing the actual items a user can select from the menu, and each item has a series of bindings that FlightGear will activate when the user selects the item.

Here's a simplified grammar:

```
[menubar] : menu*
```

```
menu : label, item*
```

```
item : label, enabled, binding*
```

The bindings are standard FlightGear bindings, the same as the ones used for the keyboard, mouse, joysticks, and the instrument panel. Any commands allowed in those bindings are allowed here as well.

Here's an example of a simple menubar with a "File" drop-down menu and a single "Quit" item:

```
<PropertyList>

  <menu>
    <label>File</label>

    <item>
      <label>Quit</label>
      <binding>
        <command>exit</command>
      </binding>
    </item>

  </PropertyList>
```

PUI menus do not allow advanced features like submenus or checkmarks. The most common command to include in a menu item binding is the 'dialog-show' command, which will open a user-defined dialog box as described in the next section.

## DIALOGS

-----

The configuration files for XML dialogs use a nested structure to set up dialog boxes. The top-level always describes a dialog box, and the lower levels describe the groups and widgets that make it up. Here is a simple, "hello world" dialog:

```
<PropertyList>

  <name>hello</name>

  <width>150</width>
  <height>100</height>
  <modal>false</modal>
  <draggable>true</draggable>
  <resizable>true</resizable>

  <text>
    <x>10</x>
    <y>50</y>
    <label>Hello, world</label>
    <color>
      <red>1.0</red>
      <green>0.0</green>
      <blue>0.0</blue>
    </color>
  </text>

  <button>
    <x>40</x>
    <y>10</y>
    <legend>Close</legend>
    <binding>
      <command>dialog-close</command>
    </binding>
  </button>

</PropertyList>
```

The dialog contains two sub-objects: a text field and a button. The button contains one binding, which closes the active dialog when the user clicks on the button.

Coordinates are pseudo-pixels. The screen is always assumed to be 1024x768, no matter what the actual resolution is. The origin is the bottom left corner of the screen (or parent dialog or group); x goes from left to right, and y goes from bottom to top.

All objects, including the top-level dialog, accept the following properties, though they will ignore any that are not relevant:

x - the X position of the bottom left corner of the object, in pseudo-pixels. The default is to center the dialog.

y - the Y position of the bottom left corner of the object, in pseudo-pixels. The default is to center the dialog.

width - the width of the object, in pseudo-pixels. The default is the width of the parent container.

height - the height of the object, in pseudo-pixels. The default is the width of the parent container.

border - the border thickness, in pseudo-pixels. The default is 2.

color - a subgroup to specify the dialogs color:

- red - specify the red color component of the color scheme.
- green - specify the green color component of the color scheme.
- blue - specify the blue color component of the color scheme.
- alpha - specify the alpha color component of the color scheme.

font - a subgroup to specify a specific font type

- name - the name of the font (excluding it's .txf extension)
- size - size of the font
- slant - the slant of the font (in pseudo-pixels)

legend - the text legend to display in the object.

label - the text label to display near the object.

property - the name of the FlightGear property whose value will be displayed in the object (and possibly modified through it).

binding - a FlightGear command binding that will be fired when the user activates this object (more than one allowed).

keynum - the key code of a key that can be used to trigger the widget bindings via keyboard (e.g. <keynum>97</keynum> for the "a" key).

key - like "keynum", but takes a character ("a", "A", "Shift-a", "Shift-A", "Ctrl-a", "%", etc.), or symbolic key name ("Tab", "Return" = "Enter", "Esc" = "Escape", "Space", "&" = "and", "<" = "&lt;", ">" = "&gt;", "F1" -- "F12", "Left", "Up", "Right", "Down", "PageUp", "PageDn", "Home", "End", "Insert"). Note that you can't use "<", ">", and "&" directly.

default - true if this is the default object for when the user presses the [RETURN] key.

visible - if set to false, hides the whole widget that it is used in, along with its children. There's no empty space reserved for such widgets. The "visible" property can also be used to hide other XML groups from the layouter.

Objects may appear nested within the top-level dialog or a "group" or a "frame" object. Here are all the object types allowed, with their special properties:

dialog  
-----

The top-level dialog box; the name does not actually appear in the file, since the root element is named PropertyList.

name - (REQUIRED) the unique name of the dialog for use with the "dialog-show" command.

modal - true if the dialog is modal (it blocks the rest of the program), false otherwise. The default is false.

draggable - false if the dialog is not draggable. The default is true.

resizable - false if the dialog is not resizable. The default is false.

nasal - Nasal definition block  
open - Nasal script to be executed on dialog open  
close - Nasal script to be executed on dialog close

All Nasal code runs in a dialog namespace. Nasal bindings can directly access variables and functions defined in an <open> block. settimer() and setlistener() functions have to be removed manually in the <close> block if they shouldn't remain active.

Example:

```
<PropertyList>

<name>sample</name>
<width>500</width>
<height>210</height>
<modal>false</modal>

<text>
...
</text>

<button>
...
</button>

</PropertyList>
```

group and frame  
-----

A group of subobjects. This object does not draw anything on the screen, but all of its children specify their coordinates relative to the group; using groups makes it easy to move parts of a dialog around.

A frame is a visual representation of a group and has a border and an adjustable background color.

Example:

```
<group>
<x>0</x>
<y>50</y>

<text>
...
</text>

<input>
...
</input>

<button>
...
</button>

</group>
```

input  
-----

A simple editable text field.

Example:

```
<input>
  <x>10</x>
  <y>60</y>
  <width>200</width>
  <height>25</height>
  <label>sea-level temperature (degC)</label>
  <property>/environment/temperature-sea-level-degc</property>
</input>
```

text  
-----

A non-editable text label.

Example:

```
<text>
  <x>10</x>
  <y>200</y>
  <label>Heading</label>
</text>

<text>
  <x>10</x>
  <y>200</y>
  <label>-9.9999</label> <!-- placeholder for width -->
  <format>%-0.4f m</format>
  <property>/foo/altitude</property>
</text>
```

checkbox  
-----

A checkbox, useful for linking to boolean properties.

Example:

```
<checkbox>
  <x>150</x>
  <y>200</y>
  <width>12</width>
  <height>12</height>
  <property>/autopilot/locks/heading</property>
</checkbox>
```

button  
-----

A push button, useful for firing command bindings.

one-shot - true if the button should pop up again after it is pushed, false otherwise. The default is true.

```

<button>
  <x>0</x>
  <y>0</y>
  <legend>OK</legend>
  <binding>
    <command>dialog-apply</command>
  </binding>
  <binding>
    <command>dialog-close</command>
  </binding>
  <default>true</default>
</button>

```

combo

-----

A pop-up list of selections.

value - one of the selections available for the combo. There may be any number of "value" fields.

Example:

```

<combo>
  <x>10</x>
  <y>50</y>
  <width>200</width>
  <height>25</height>
  <property>/environment/clouds/layer[0]/type</property>
  <value>clear</value>
  <value>mostly-sunny</value>
  <value>mostly-cloudy</value>
  <value>overcast</value>
  <value>cirrus</value>
</combo>

```

list

----

like "combo", but displays all values in a scrollable list box with slider on the right side. Updates the <property> to the selected entry. On <dialog-update> re-scans the <value> nodes and updates the list.

airport-list

-----

like "list", but fills the list automatically with all airports known to FlightGear. Calls bindings on airport selection and returns the selected entry in <property> on dialog-apply. Interprets <property> as search term on dialog-update.

property-list

-----

like "list", but shows a list of properties from the global property tree. The widget handles navigation in the property tree. It calls its bindings on property selection and returns the path of the selected property in <property> on dialog-apply. It's up to the caller to check if the path belongs to a dir node or a value node. The widget shows the contents of the dir property given in <property> on dialog-apply. It does *\*not\** handle setting of property values! Clicking on some entries with the "control" or "shift" key pressed has a special meaning:

Ctrl +

"." -> toggle verbose mode (shows flags, listeners, dir-values)  
".." -> go to root node  
(bool) -> toggle bool value

Shift +

"." -> dump contents of that tree level to the terminal

The flags printed after the node type have the following meaning:

r -> read protected  
w -> write protected  
R -> trace read operations (in the terminal window)  
W -> trace write operations  
A -> archive bit set  
U -> user archive bit set  
P -> preserved bit set (value is preserved on sim-reset)  
T -> property is "tied"  
  
Ln -> number of listeners attached to this node

select

-----

A box with arrow buttons that cycle through a list of values.

Example:

```
<select>
  <x>10</x>
  <y>50</y>
  <width>200</width>
  <height>25</height>
  <property>/sim/aircraft</property>
  <value>bo105</value>
  <value>ufo</value>
</select>
```

slider

-----

A horizontal or vertical slider for setting a value.

vertical - true if the slider should be vertical, false if it should be horizontal. The default is false.

min - the minimum value for the slider. The default is 0.0.

max - the maximum value for the slider. The default is 1.0.



step - set to non-null if slider should move in steps. The default is 0.0 (off).

pagestep - set to non-null to enable page-stepping. The default is 0.0 (off).

fraction - size of the slider handle. Range: 0..1. The default is 0.0 (minimum).

Example:

```
<slider>
  <x>10</x>
  <y>50</y>
  <width>200</width>
  <property>/environment/visibility-m</property>
  <min>5</min>
  <max>50000</max>
</slider>
```

dial

----

A circular dial for choosing a direction.

wrap - true if the dial should wrap around, false otherwise. The default is true.

min - the minimum value for the dial. The default is 0.0.

max - the maximum value for the dial. The default is 1.0.

Example:

```
<dial>
  <x>10</x>
  <y>50</y>
  <width>20</width>
  <property>/environment/wind-from-direction-deg</property>
  <min>0</min>
  <max>360</max>
</dial>
```

textbox

-----

The text will be retrieved/buffered from/within a specified property tree, like:

```
<textbox>
  <!-- position -->
  <x>100</x>
  <y>100</y>

  <!-- dimensions -->
  <width>200</width>
  <height>400</height>

  <property>/gui/path-to-text-node/contents</property>

  <slider>15</slider> <!--width for slider -->
  <wrap>false</wrap> <!-- don't wrap text; default: true -->
  <top-line>0</top-line> <!-- line to show at top, -ve numbers: show last line -->
```

```

    <editable>true</editable> <!-- if the puLargeInput is supposed to be editable -->
</textbox>

```

```

hrule/vrule
-----

```

Draws a horizontal/vertical line that, by default, expands to full width/height. Its thickness can be set with <pref-height>/<pref-width>.

```

<hrule>
  <color>
    <red>1.0</red>
    <green>0.0</green>
    <blue>0.0</blue>
  </color>
  <pref-height>2</pref-height>
</hrule>

```

```

GLOBAL SETTINGS ("THEMES")
-----

```

FlightGear reads GUI style information from /sim/gui/, which is by default loaded from file \$FG\_ROOT/gui/style.xml. This file contains one <font> and one <colors> group:

```

global font settings
-----

```

```

<sim>
  <gui>
    <font>
      <name type="string">Helvetica.ttf</name>
      <size type="float">15</size>
      <slant type="float">0</slant>
    </font>
  </gui>
</sim>

```

<name> can either be the name of a built-in bitmap font (one of: "FIXED\_8x13", "FIXED\_9x15", "TIMES\_10", "TIMES\_24", "HELVETICA\_10", "HELVETICA\_12", "HELVETICA\_14", "HELVETICA\_18", "SANS\_12B"), or the name of a texture font in the \$FG\_FONT directory. \$FG\_FONT is by default set to \$FG\_ROOT/Fonts/. Properties <size> and <slant> are only applied to texture fonts, and otherwise ignored.

```

global color settings
-----

```

These define the color of the splash screen font, and the color of the GUI elements. All colors are in /sim/gui/colors/ and follow the same pattern:

```

<sim>
  <gui>
    <colors>
      <!-- splash screen font color; ignores <alpha> value -->

```

```

    <splash>
    <red type="float">1.0</red>
    <green type="float">0.9</green>
    <blue type="float">0.0</blue>
    </splash>
  </colors>
</gui>
</sim>

```

As listed above, FlightGear implements several GUI elements:

|     |           |                |         |          |            |
|-----|-----------|----------------|---------|----------|------------|
| (1) | "dialog"  | "group"        | "frame" | "hrule"  | "vrule"    |
|     | "list"    | "airport-list" | "input" | "text"   | "checkbox" |
|     | "radio"   | "button"       | "combo" | "slider" | "dial"     |
|     | "textbox" | "select"       |         |          |            |

The underlying plib library uses six colors for each GUI element. These are:

|     |              |              |             |
|-----|--------------|--------------|-------------|
| (2) | "background" | "foreground" | "highlight" |
|     | "label"      | "legend"     | "misc"      |

"button", for example, uses the first four colors from (2), while it ignores "legend" and "misc" color. "text" only uses "label", and ignores the rest. In some cases the use of colors isn't obvious and you have to try or look up the plib sources to be sure. GUI colors can be defined for each of the categories from (1) and (2), and for combinations of them:

|     |                 |              |      |
|-----|-----------------|--------------|------|
| (3) | "button-legend" | "input-misc" | etc. |
|-----|-----------------|--------------|------|

FlightGear has default colors for (2) built-in. Let's call them (0). And this is how colors for individual GUI elements are determined, if, for example, a button is to be drawn:

For the button's background:

- read the hard-coded default "background" color from (0) as base
- merge the global "background" color from (2) in (if defined)
- merge a global color "button-background" from (3) in (if defined)
- merge a specific <color> from the dialog's XML file in (if defined)

Repeat the four steps for the button's "foreground", "highlight", etc. color.

If you write a style file, you'll most likely start with the colors from (2):

```

<sim>
  <gui>
    <colors>
      <background>
        <red type="float">0.6</red>
        <green type="float">0.0</green>
        <blue type="float">0.0</blue>
        <alpha type="float">1.0</alpha>

```

```
</background>
```

```
<foreground>
```

```
...
```

This makes all dialogs dark red. But you don't, for example, want buttons to be red, but yellow. So you define another color for buttons:

```
<button>
```

```
<red type="float">1.0</red>
```

```
<green type="float">0.9</green>
```

```
<blue type="float">0.0</blue>
```

```
<alpha type="float">1.0</alpha>
```

```
</button>
```

```
...
```

This sets all of a button's six colors (2) to some shades of red. plib does this automatically. The lower and right border ("foreground") will be darker, the upper and left border will be lighter ("highlight"). If you aren't happy with plib's choice, you can set each of the colors explicitly. Let's say, we want the text on the button blue (3):

```
<button-legend>
```

```
<red type="float">0.3</red>
```

```
<green type="float">0.3</green>
```

```
<blue type="float">1.0</blue>
```

```
<alpha type="float">1.0</alpha>
```

```
</button-legend>
```

```
...
```

To set the cursor color from input fields, you'd define "input-misc", etc.

You can change colors and font at runtime. Just open the property browser, go to /sim/gui/colors and change whatever you like. The new color will only take effect, though, if you re-init the GUI. There's a menu entry for that, and you can define a key binding for it:

```
<key n="99">
```

```
<name>c</name>
```

```
<desc>Re-init GUI</desc>
```

```
<binding>
```

```
<command>reinit</command>
```

```
<subsystem>gui</subsystem>
```

```
</binding>
```

```
</key>
```

Note that this will currently close all open dialogs!

```
__end__
```

## 17 Hud

This document describes the \*new\* HUD system that will be first released with fgfs >0.9.10. For the old system see \$FG\_ROOT/Docs/README.xmlhud. Note that the old system is scheduled for removal, and that the new system is work in progress. So it's up to you to choose the lower risk. :-)

#####

A HUD configuration file may contain 3 types of information:

- (1) global settings
- (2) HUD instrument definitions
- (3) imports of further HUD config files

(1) global settings =====

These can be used to override settings in the global property tree. Currently only bool <enable-3d> is supported. It allows a HUD to define itself if it is a 2D HUD (false) or a 3D HUD (true). 2D HUDs always remain in the screen plane, while 3D HUDs always remain in a position relative to the aircraft.

Example:

```
<enable-3d>true</enable-3d>
```

(2) HUD instrument definitions =====

These define one single HUD "item" (instrument or label), and consist of several properties. Some of those are standardized property groups that can be used in many places. These shall be explained first.

(2.1) standardized property groups -----

1. <condition> group
2. input channel group
3. <option>s

(2.1.1) <condition> .....

These define conditions that are either "true" or "false". They are used to hide/unhide whole items, or to set other item states (blinking on/off) etc. You find detailed documentation about them in \$FG\_ROOT/Docs/README.conditions.

### (2.1.2) input channel groups .....

These define an input channel to the HUD instrument and serve as interface between property system and the instrument. A complete channel definition looks like this (defaults in comments):

```
<input>
  <property>/position/altitude-agl-ft</property>  <!-- no default -->
  <factor>0.3048</factor>                        <!-- 1.0 -->
  <offset>2.0</offset>                            <!-- 0.0 -->
  <damp>1.5</damp>                                <!-- 0.0 (no damping) -->
  <min>0.0</min>                                  <!-- -infinity -->
  <max>10000</max>                                <!-- +infinity -->
</input>
```

Input channels are only called <input> for instruments that only have one channel. Other instruments may have two or more channels, called <bank-input>, <pitch-input> etc. All of them will have the same member properties and behave the same.

An input channel will preprocess the raw property value for the HUD instrument. The property may be of any type (bool, int, long, float, double, string), but not all types will make sense in every situation. The HUD instrument will only see the final value, which is calculated as:

```
v = <property> * <factor> + <offset>
if (<damp>)    v = EWMA_lowpass(v, <damp>)
if (v < <min>) v = <min>
if (v > <max>) v = <max>
```

The EWMA\_lowpass filter (Exponentially Weighted Moving Average) is calculated like so:

```
coeff = 1.0 - 1.0 / 10^<damp>
v = average = (average * coeff) + (v * (1.0 - coeff))
```

That is, a <damp> value of 0 will cause no damping. A damping value of 1 will make a coefficient of 0.9, which means that the resulting value will be 9/10 of the average plus 1/10 of the new value. A damping value of 2 will make a coefficient of 0.99 and hence result in a value of 99/100 the average plus 1/100 the new value etc. The higher the <damp> value, the more damped will the output value be.

### 2.1.3 <option> .....

Most HUD instruments accept one or more options from a common set. It will be explained in the respective instrument descriptions which options are actually used by that instrument. Possible values are:

```
<option> autoticks </option>
<option> vertical </option>   \___orientation of <tape>
<option> horizontal </option> /
<option> top </option>        \
<option> left </option>       |___place of numbers in <tape>, <gauge>
<option> bottom </option>    |   top/bottom for turn-bank-indicator, etc.
```

```

<option> right </option>          /
<option> both </option>           _left/right for vert. and top/bottom for hor.
<option> noticks </option>
<option> arithtic </option>
<option> decitics </option>
<option> notext </option>         ___no numbers on <tape>

```

Example:

```

<tape>
  <option>left</option>
  <option>vertical</option>
  ...
</tape>

```

## (2.1) properties common to all instruments -----

All HUD instruments will accept the following common properties (shown on a <tape> instrument):

```

<tape>
  <name>foo tape</name>
  <x>-100</x>                <!-- 0 == center -->
  <y>-60</y>                 <!-- 0 == center -->
  <width>20</width>          <!-- 0 -->
  <height>120</height>      <!-- 0 -->
  <condition>...</condition> <!-- see section 2.1.1; default: true -->
  ...
</tape>

```

The <name> is only a description for the instrument to make reading the config easier. It's output in --log-level=info, but not otherwise used. The coordinates define the place and size of the instrument. They are relative to the origin of their parent, which is the middle of the HUD/screen by default. Positive <x> are on the right, positive <y> in the upper half. The <condition> hides/reveals the whole instrument.

## (2.2) HUD instruments -----

### (2.2.1) <label> .....

Draws a formatted string or number.

Text:

```

<format>  ... printf-style format with only one % item. Example: "%2.3lf ft"
<prefix>  ... prefix text \__ in addition to the <format>
<postfix> ... postfix text /
<halign>  ... one of "left", "center" (default), "right".

```

Box:

```
<box>      ... draw box around label (default: false)
<option>    ... one of (left|right|top|bottom) ... draw arrow on this side
<pointer-width> ... size of pointer base
<pointer-lenfth> ... distance of base--peak

<blinking>
  <interval>      ... on/off-time in seconds (default: -1 == off)
  <condition>...</condition> ... see section 2.1.1      (default: true)
</blinking>
```

TODO:

```
<digit>    ... number of insignificant digits (those will be printed smaller)
```

Example:

```
<label>
  <name>G Load</name>
  <x>-40</x>
  <y>25.5</y>
  <width>1</width>
  <height>1</height>

  <input>
    <property>/accelerations/pilot/z-accel-fps_sec</property>
    <factor>-0.03108095</factor>
    <damp>1.3</damp>
  </input>

  <format>%2.1f</format>
  <halign>right</halign>
  <box>true</box>
  <option>bottom</option>    <!-- pointer on the lower edge -->

  <blinking>
    <interval>0.25</interval>
    <condition>
      <or>
        <less-than>      <!-- G load > 2.0 -->
          <property>/accelerations/pilot/z-accel-fps_sec</property>
          <value>-64.3481</value>
        </less-than>

        <greater-than>   <!-- G load < -1.0 -->
          <property>/accelerations/pilot/z-accel-fps_sec</property>
          <value>31.17405</value>
        </greater-than>
      </or>
    </condition>
  </blinking>
</label>
```



(2.2.2) <tape> .....

SCALE:

input  
major-divisions  
minor-divisions  
modulo  
display-span

TAPE:

tick-bottom  
tick-top  
tick-right  
tick-left  
cap-bottom  
cap-top  
cap-right  
cap-left  
marker-offset  
enable-pointer  
zoom  
  
pointer-type (moving|fixed)  
tick-type (circle|line)  
tick-length (constant|variable)

(2.2.3) <dial> .....

SCALE:

input  
major-divisions  
minor-divisions  
modulo  
display-span

TAPE:

radius  
divisions

(2.2.4) <gauge> .....

SCALE:

input  
major-divisions  
minor-divisions  
modulo  
display-span

(2.2.5) <turn-bank-indicator> .....  
 bank-input  
 sideslip-input  
 gap-width  
 bank-scale

(2.2.6) <ladder> .....  
 pitch-input  
 roll-input  
 display-span  
 divisions  
 screen-hole  
 compression-factor  
 enable-fuselage-ref-line  
 enable-target-spot  
 enable-velocity-vector  
 enable-drift-marker  
 enable-alpha-bracket  
 enable-energy-marker  
 enable-climb-dive-marker  
 enable-glide-slope-marker  
 glide-slope  
 enable-energy-marker  
 enable-waypoint-marker  
 enable-zenith  
 enable-nadir  
 enable-hat  
 type (pitch|climb-dive)

(2.2.7) <runway> .....  
 arrow-scale  
 arrow-radius  
 line-scale  
 scale-dist-nm  
 outer\_stipple  
 center-stipple  
 arrow-always

reads directly:  
 /position/altitude-agl-ft,  
 /sim/view[0]/config/pitch-pitch-deg  
 /sim/view[0]/config/pitch-heading-deg

(2.2.8) <aiming-reticle> .....

Draws MIL-STD-1787B aiming reticle. Size of bullet and inner circle are determined from <width>. The outer circle radius is changeable at runtime.

```
<active-condition> ... true:  stadiametric (4.2.4.4)  (default)
                      false: standby (4.2.4.5)
<diameter-input>   ... input channel: diameter of outer circle relative to
                      inner circle; default: 2.0 (= twice as big)
```

(3) <import> =====

Imports another HUD config into the current one. This can be a file defining a single instrument (\$FG\_ROOT/Huds/Instruments/\*.xml), a set of instruments (\$FG\_ROOT/Huds/Sets/\*.xml) or a mixture of both (for example a complete HUD on its own). The x/y offsets moves the reference point for the included items relative to the current reference point.

```
<import>
  <path>Huds/Sets/controls.xml</path>
  <x-offset>-100</x-offset>
  <y-offset>70</y-offset>
</import>
```

Imported files can import further files. This is allowed for up to 10 levels. This is an arbitrary number and can easily be changed in the code if necessary.

When fgfs is called with --log-level=info, then it outputs a graphical trees of all loaded/imported files, with the instruments shown as leafs.

## 18 Introduction

### Internals

-----

The core of FlightGear is the property system. This is a tree like internal representation of global variables. The property system is explained more in detail later on.

FlightGear' way of doing things is breaking it up into small pieces. There is (for example) animation code that reacts on property changes. There is also a Flight Dynamics model (FDM) that (amongst other things) updates properties. There is a menu system that can display and alter properties. Then we have sound code that plays sound based on ... properties.

Maybe you see a pattern evolve by now.

All subsystems are almost self containing. Most of the time they only read the values of some properties, and sometimes they alter other properties. This is the basic way of communicating between subsystems.

### Property System

-----

The property system is best described as an in-memory LDAP database which holds the state of global variables. The system has a tree like hierarchy (like a file system) and has a root node, sub nodes (like subdirectories) and end-nodes (variables).

All variables are kept internally as raw values and can be converted to any other supported type (boolean, int, float double and string).

Like a file system, every node can be accessed relative to the current node, or absolute to the root node.

The property system also allows aliasing nodes to other nodes (like symbolic linking files or directories to other files or directories) and may be assigned read-only or read-write.

If necessary it would be possible for parts of the program to hold it's own property tree, which is inaccessible from the global property tree, by keeping track of it's own root-node.

Property I/O code allows one to easily read the tree from, or write the tree to an XML file.

### Subsystems

-----

To add a new subsystem you would have to create a derived class from SGSubsystem and define at least a small set of functions:

```
class FGFX : public SGSubsystem
{
public:

    FGFX ();
    virtual ~FGFX ();

    virtual void init ();
```

```

    virtual void reinit ();
    virtual void bind ();
    virtual void unbind ();
    virtual void update (double dt);
}

```

The init() functions should make sure everything is set and ready so the update() function can be run by the main loop. The reinit() function handles everything in case of a reset by the user.

The bind() and unbind() functions can be used to tie and untie properties.

After that you can register this class at the subsystem manager:

```

globals->add_subsystem("fx", new FGFX);

```

Now the subsystem manager calls the update() function of this class every frame. dt is the time (in seconds) elapsed since the last call.

## Scripting

-----

The scripting language Nasal can also read and modify properties but it can also be incorporated into the menu system. The documentation for Nasal can be found here: <http://www.plausible.org/nasal/flightgear.html>

## 19 IO

This document describes how to invoke FlightGear's generic IO subsystem.

FlightGear has a fairly flexible generic IO subsystem that allows you to "speak" any supported protocol over any supported medium. The IO options are configured at runtime via command line options. You can specify multiple entries if you like, one per command line option.

The general form of the command line option is as follows:

```
--protocol=medium,direction,hz,medium_options,...
```

```
protocol = { native, nmea, garmin, fgfs, rul, pve, ray, etc. }
```

```
medium = { serial, socket, file, etc. }
```

```
direction = { in, out, bi }
```

```
hz = number of times to process channel per second (floating  
point values are ok.
```

Generic Communication:

```
--generic=params
```

With this option it is possible to output a pre-configured ASCII string or binary sequence using a predefined separator. The configuration is defined in an XML file located in the Protocol directory of the base package.

params can be:

```
serial port communication:    serial,dir,hz,device,baud,protocol
```

```
socket communication:        socket,dir,hz,machine,port,style,protocol
```

```
i/o to a file:                file,dir,hz,filename,protocol
```

See README.protocol for how to define a generic protocol.

Serial Port Communication:

```
--nmea=serial,dir,hz,device,baud
```

```
device = OS device name of serial line to be open()'ed
```

```
baud = {300, 1200, 2400, ..., 230400}
```

example to pretend we are a real gps and output to a moving map application:

```
--nmea=serial,out,0.5,COM1,4800
```

Note that for unix variants you might use a device name like "/dev/ttyS0"

Socket Communication:

```
--native=socket,dir,hz,machine,port,style
```

```
machine = machine name or ip address if client (leave empty if server)
```

```
port = port, leave empty to let system choose
```

```
style = tcp or udp
```

example to slave one copy of fgfs to another

```
fgfs1: --native=socket,out,30,fgfs2,5500,udp
```

```
fgfs2: --native=socket,in,30,,5500,udp --fdm=external
```

This instructs the first copy of fgfs to send UDP packets in the native format to a machine called fgfs2 on port 5500.

The second copy of fgfs will accept UDP packets (from anywhere) on port 5500. Note the additional --fdm=external option. This tells the second copy of fgfs to not run the normal flight model, but instead set the FDM values based on an external source (the network in this case.)

#### File I/O:

```
--garmin=file,dir,hz,filename
```

filename = file system file name

example to record a flight path at 10 hz:

```
--native=file,out,10,flight1.fgfs
```

example to replay your flight

```
--native=file,in,10,flight1.fgfs --fdm=external
```

You can make the replay from a file loop back to the beginning when it reaches the end of the file with the "repeat" flag:

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

With a numeric argument, FlightGear will exit after that number of repeats.

```
--generic=file,in,20,flight.out,playback,repeat,5
```

#### Moving Map Example:

Per Liedman has developed a moving map program called Atlas ([atlas.sourceforge.net](http://atlas.sourceforge.net)) The initial inspiration and much code came from Alexei Novikov.

The moving map supports NMEA format input either via network or via serial port. Either way will work, but this example demonstrates the use of a socket connection.

Start up fgfs with:

```
fgfs --nmea=socket,out,0.5,atas-host-name,5500,udp
```

Start up the Atlas program with:

```
Atlas --udp=5500 --fgroot=path-to-fg-root --glutfonts
```

Once both programs are running, the Atlas program should display your current location. Atlas is a really nifty program with many neat options such as the ability to generate and use background bitmaps that show the terrain, cities, lakes, oceans, rivers, etc.

#### HTTP Server Example

You can now interact with a running copy of FlightGear using your web browser. You can view all the key internal variables and even

change the ones that are writable. If you have support in your favorite [scripting] language for interacting with an http server, you should be able to use this as a mechanism to interface your script with FlightGear.

Start up fgfs with the `--httpd=<port#>` option:

For example:

```
fgfs --httpd=5500
```

Now point your web browser to:

```
http://host.domain.name:5500/
```

When a value is displayed, you can click on it to bring up a form to assign it a new value.

ACMS flight data recorder playback

```
fgfs --fdm=acms --generic=file,in,1,<path_to_replay_file>,acms
```



## 20 Joystick

Replaced by Docs/README.Joystick.html in the base package.

## 21 JSBSim

### JSBSim

JSBSim is an ongoing attempt at producing an OO Flight Dynamics Model (FDM) to replace LaRCsim as the default FDM for FlightGear. It can also be used standalone.

JSBSim uses config files to represent aircraft, engines, propellers, etc. Also, the flight control system is described in the config file. Normally, for use with FlightGear, the config files are named this way [case is significant]:

```
<FG_ROOT>/Aircraft/<aircraft name>/<aircraft name>.xml
```

Engines are named like this:

```
<FG_ROOT>/Engines/<engine name>.xml
```

Aircraft and engine config files are present in the FGFS Base package which must be downloaded. See the FlightGear web site for more information.

### How to run FGFS using JSBSim

All the various FDMs are currently compiled into FGFS. You can specify which FDM you want at run time. You can also specify which aircraft you want. Currently, for JSBSim only the X-15 and C-172 aircraft are available. Here is an example command line used to start up FlightGear using JSBSim as the FDM:

```
fgfs --fdm=jsb --aircraft=X15 --units=feet --altitude=60000 --uBody=2000 --wBody=120
```

or,

```
fgfs --fdm=jsb --aircraft=c172
```

[Note: uBody is the forward velocity of the aircraft, wBody is the downward velocity - from the aircraft point of view. This essentially means that the aircraft is going forward fast and has an angle of attack of about 4 degrees or so]

The first command line sets up the initial velocity and altitude to allow the X15 to glide down. Note that if you fire up the engine, it will burn for only about two minutes and then run out of fuel - but you will go very, very fast! The second command line example will start up the C172 on the end of the runway.

Check out the JSBSim home page at <http://jsbsim.sf.net>. Please report any bugs to [jsb@hal-pc.org](mailto:jsb@hal-pc.org), or [apeden@earthlink.net](mailto:apeden@earthlink.net), or post on the jsbsim web site using the SourceForge bug tracking system for the project.

JSBSim is written by Jon S. Berndt and Tony Peden with contributions by other FlightGear programmers, as well.

## 22 Jsclient

Start flightgear with

```
fgfs --jsclient=socket,in,<hz>,,<port>,udp \  
    --prop:/jsclient/axis[i]="/property/you/want/to/control" \  
    --prop:/jsclient/axis[i+1]="/another/property/you/want/to/control" ...
```

eg:

```
# fgfs --aircraft=yf23-yasim --airport=KEMT --jsclient=socket,in,5,,16759,udp \  
    --prop:/jsclient/axis[0]="/controls/flight/spoilers" \  
    --prop:/jsclient/axis[1]="/radios/comm/volume"
```

Start the server on the machine with the remote gameport:

```
JsServer <host> <port>
```

eg:

```
# JsServer 192.168.1.1 16759
```

(JsServer can be started before or after fgfs)

## 23 Layout

I just committed an implementation of GUI layout management, ported over from my game project last year\*. What this means is that you no longer need to position your widgets manually in dialogs, and can instead lay them out in tables and boxes like the pros do. :) I've redone a few of the dialogs using the new scheme (I'm especially proud of the autopilot dialog: <http://plausible.org/andy/autopilot-new.png>), so you can see what the possibilities look like.

\* FWIW, this is almost the last of my useful code from last spring. Nasal and the Plib vertex splitting code are two other bits that were useful in isolation. I also had a terrain engine and stencil shadow implementation, but those weren't really production quality.

Basically, the implementation is a preprocessor on top of the existing dialog properties, which sets x/y/width/height values based on constraints. The <group> objects, including the top-level one which represents the whole dialog, can now have a <layout> property, which can be "hbox", "vbox", or "table".

The boxes simply lay out their children in order, either top-to-bottom or left-to-right. The box name comes from Qt and Gtk, but this is also the same thing that Java calls a "flow layout", or what the Tk "packer" does. You can set "constraint" properties on the children, to give the layout manager hints as to how to place the children. For the boxes, these are:

equal: The box manager makes sure that all the widgets with this constraint set to true get equal sizes big enough to fit the largest one. This is very useful for button boxes to make the "OK" and "Cancel" buttons match, for example.

stretch: Cells with "stretch" set to true get all the extra space, if any, the box has to allocate. These are useful for alignment purposes, especially when combined with <empty> "widgets" (which are ignored by the dialog creation code, but honored by the layout engine).

The table layout will be a little more familiar to anyone with HTML experience. Children of tables get the following constraints:

row: The row number containing the upper left corner of the widget. Table rows are zero-indexed.

col: The column number containing the upper left corner of the widget. Table columns are zero-indexed.

rowspan: The number of rows spanned by the widget. Defaults to one.

colspan: The number of columns spanned by the widget. Defaults to one.

Inside of each "cell", regardless of parent layout, there are some constraints that are used to position the widget within the space available:

halign: The horizontal alignment. Can be "left", "right", "center", or "fill" (i.e. stretch to available space).

valign: The vertical alignment. Can be "top", "bottom", "center", or "fill".

padding: The number of pixels to leave between the edge of the cell and the widget.

pref-height:

pref-width: Overrides the default preferred size of the widget. Note that this is the size of the widget only, not the cell (which includes padding).

Also, the padding values for cells in a group can be set to a default value with a <default-padding> property on the group widget.

Some will ask why didn't I implement this as part of Pui. The problem is the pui just isn't set up for it. Not only is there no notion of "preferred" size for a widget, there isn't anything remote like a "constraint" system for attaching arbitrary values to widgets. With the property system, I have that for free (the original code was written to work with Nasal objects, btw). I can do the layout with the properties and on the properties, and our existing dialog code hardly needs to change at all.

Anyway, give it a try and see if I've broken anything. Also, note that some of these changes *do* modify the visual appearance of the GUI. I think it looks better, but opinions will no doubt vary. Shout if you hate it.

And finally, the text alignment doesn't quite look right with current plib due to some minor rendering bugs. Bug Steve to apply the patch I submitted a week or so ago. :)

Andy

## 24 Logging

### Logging in FlightGear

[Note: JSBSim also has its own independent logging facilities, which are not discussed here.]

FlightGear can log any property values at any interval to one or more CSV files (which can be read and graphed using spreadsheets like Gnumeric or Excel). Logging is defined in the '/logging' subbranch of the main property tree; under '/logging', each '/log' subbranch defines a separate log with its own output file and interval. Here is a simple example that logs the rudder and aileron settings every second (1000ms) to the file steering.csv, using a comma (the default, anyway) as the field delimiter:

```
<PropertyList>
<logging>
  <log>
    <enabled>true</enabled>
    <filename>steering.csv</filename>
    <interval-ms>1000</interval-ms>
    <delimiter>,</delimiter>
    <entry>
      <enabled>true</enabled>
      <title>Rudder</title>
      <property>/controls/flight/rudder</property>
    </entry>
    <entry>
      <enabled>true</enabled>
      <title>Ailerons</title>
      <property>/controls/flight/aileron</property>
    </entry>
  </log>
</logging>
</PropertyList>
```

Each 'log' subbranch contains a required 'enabled' property, an optional 'filename' property (defaults to "fg\_log.csv"), an optional 'delimiter' property (defaults to a comma), an optional 'interval-ms' property (defaults to 0, which logs every frame), and a series of 'entry' subbranches. The 'delimiter' property uses only the first character of the property value as the delimiter. Note that the logger does no escaping, so you must choose a delimiter that will not appear in the property values (that's not hard, since most of the values are numeric, but watch for commas in the titles).

Each 'entry' subbranch contains a required 'enabled' property, a 'property' property specifying the name of the property to be logged, and an optional 'title' property specifying the title to use in the CSV file (defaults to the full path of the property). The elapsed time in milliseconds since the start of the simulation is always included as the first entry with the title "Time", so there is no need to include it explicitly.

Here's a sample of the logging output for the above log:

```
Time,Rudder,Ailerons
6522,0.000000,0.000000
7668,-0.000000,0.000000
8702,-0.000000,0.000000
9705,-0.000000,0.000000
```

```
10784,-0.000000,0.000000
11792,-0.000000,0.000000
12808,-0.000000,-0.210000
13826,-0.000000,-0.344000
14881,-0.000000,-0.066000
15901,-0.000000,-0.806000
16943,-0.000000,-0.936000
17965,-0.000000,-0.534000
19013,-0.000000,-0.294000
20044,-0.000000,0.270000
21090,-0.000000,-1.000000
22097,-0.000000,-0.168000
```

Note that the requested interval is only a minimum; most of the time, the actual interval is slightly longer than the requested one.

The easiest way for an end-user to define logs is to put the log in a separate XML file (usually under the user's home directory), then refer to it using the `--config` option, like this:

```
fgfs --config=log-config.xml
```

The output log files are always relative to the current directory.

--

David Megginson, last updated 2002-02-01

## 25 Materials

### README.materials

This README describes the materials.xml file format. It is targeted at those wanting to change the appearance of the scenery in FlightGear.

The materials file used by FlightGear is set in the /sim/rendering/materials-files property. It is read on startup, and can be reloaded in-sim from the "Reload Materials" item in the Debug menu.

The materials file consists of one or more <region> elements. Each <region> contains one or more geographical <area> elements, defining a rectangle (lat1/lon1, lat2/lon2), and a set of <material> elements which describes a single visually distinct terrain material in the FG world which will be used to render one of more scenery landclasses (for example Grass or Town). When determining the material to use for a given landclass at a given lat/lon, the <region> elements are checked in order and the <condition> element of the materials evaluated. The \_last\_ matching material definition is used. So more specific regions and materials definitions should be put towards the bottom of the materials file.

The rest of this document describes the children tags of the <material> entry.

**name** : Scenery type names that map to this material. These are typically taken from landclass definitions created by TerraGear. Multiple scenery types may map to a single material. This is recommended to minimize texture memory usage.

**condition** : A condition statement used to activate the material. Note that this is evaluated once at start-up.

**texture** : A relative path to an SGI RGB, PNG or DDS file containing a texture for the material. RGB and PNG are recommended for platform compatibility. You may define more than one <texture> element, in which case the scenery loader will choose one texture for each contiguous set of scenery triangles.

**texture-set** : If using an effect (see below), it may be necessary to define more than one texture. The texture-set element has multiple <texture> element children which may then be referenced by the effect. You may define more than one <texture-set> element, in which case the scenery loader will choose one texture for each contiguous set of scenery triangles.

**object-mask** : An optional bitmap file used to control random placement of lights, buildings and vegetation on the terrain. The green channel mask is used for random vegetation placement, the blue channel for buildings and lights, and the red channel controls the rotation of buildings (0.0 is North, 0.5 is South). Fractional colour values can be used to give a probability of placement. Multiple object-masks may be defined to match up with <texture> or <texture-set> elements.

**effect** : The effect to be used for this material. (default: Effects/terrain-default)

ambient, diffuse, specular, emissive, and shininess are copied into the parameter section of the effect created for this material.

**parameters** : Additional parameters to be used in the effect. See README.effects for format information.

**wrapu** : True if the texture should repeat horizontally over a surface, false if it should not repeat (default: true).



wrapv : True if the texture should repeat vertically over a surface, false if it should not repeat (default: true).

mipmap : True if the texture should be mipmapped, false otherwise. (default: true).

xsize : The horizontal size of a single texture repetition, in meters.

ysize : the vertical size of a single texture repetition, in meters

light-coverage : The coverage of a single point of light in  $m^2$ . 0 indicates no lights at all. Minimum value is  $1000m^2$ . May be masked by the blue channel of an object-mask. Lights are all generated 3m above the surface, and have random colour (50% yellow, 35% white, 10% orange, 5% red)

ambient : The ambient light colour for the material, specified as separate r, g, b, a components (default: all color components 0.2, alpha 1.0).

diffuse : The diffuse light colour for the material, specified as separate r, g, b, a components (default: all color components 0.8, alpha 1.0).

specular : The specular light colour for the material, specified as separate r, g, b, a components (default: all color components 0.0, alpha 1.0).

emissive : The emissive light colour for the material, specified as separate r, g, b, a components (default: all color components 0.0, alpha 1.0).

solid : Whether the surface is solid from an FDM perspective. If it is not solid, it is assumed that the material models a fluid (water) surface. (default: true).

friction-factor : The friction factor for that material. The normalized factor can be used by a FDM to post-multiply all contact friction forces with that factor. That is the more slippery a material is the smaller this value should be. (default: 1.0 for Dry concrete/Asphalt).

rolling-friction : the gear rolling rolling-friction coefficient for this particular material. (default: 0.02 for Dry concrete/Asphalt).

bumpiness : normalized bumpiness factor for this particular terrain. (default: 0.0 for a smooth surface).

load-resistance : a pressure value how much force per surface area this surface can carry without deformation. The value should be in  $N/m^2$  (default:  $1e30$ ).

glyph : group that defines one letter/digit/symbol in a font texture  
sub-entries: name, left (default: 0.0), right (default: 1.0)  
(left and right describe the horizontal position in the texture.)

wood-coverage : The coverage of trees in areas marked as woodland in  $m^2$ . A lower number means a higher density of trees. A value of 0 indicates no woods. May be masked by the green channel of an object-mask. (default: 0)

tree-range-m : The range at which trees become visible. Note that this is not absolute, as trees are loaded in blocks. A lower number means trees will not become visible until you are closer.

tree-texture : A texture to use for the trees. Typically this will contain around 8 different trees in a row, duplicate 4 times. From bottom to top, the rows contain  
\* summer textures  
\* summer snow texture

\* winter texture  
\* winter snow texture

Each tree must have space at the top. For a 512x512 texture sheet, this should be 8 pixels. Otherwise subsequent rendering results in "top hats" above trees in the distance where the trunk of the tree above in the textures sheet bleeds downwards when the mipmaps are generated.

tree-varieties : The number of different trees defined in the tree-texture horizontally. (default: 1)

tree-height-m : The average height of the trees. Actual tree height will vary by +/- 50%. (default: 0)

tree-width-m : The average width of the tree cover. Actual tree width will vary by +/- 50%. (default: 0)

tree-max-density-angle-deg : The slope angle at which trees begin to thin out as the slope is too steep to support the full coverage. Shallower slopes have maximum wood-coverage. Steeper slopes have fewer trees. (default : 45)

tree-zero-density-angle-deg : The angle at which the slope is too steep to support significant vegetation. Steeper slopes have no trees. (default : 60)

object-max-density-angle-deg : The angle at which objects and buildings become less dense due to a steep slope. (default : 20)

object-zero-density-angle-deg : The angle at which the slope is too steep to build on. No object/buildings will be placed on slopes steeper than this. (default : 30)

object-group : A group of random objects to be placed on the surface. Contains <range-m> and one or more <object> children.

range-m : The distance at which objects within this object-group become visible. Note that for realism, 60% of the objects will become visible at <range-m>, 30% at 1.5\*<range-m>, and 10% at 2\*<range-m>. (default: 2000)

object : A set of random objects to be placed. Contains <coverage-m2>, <path> and <heading> children.

coverage-m2 : The coverage of a single object in m2. Lower values mean a higher density. Minimum value is 1000.

spacing-m : The minimum space between this object and any other on the surface in meters. This helps to avoid objects being placed ontop of each other. (default 20)

path : Path relative to FG\_ROOT to a model definition, usually .ac or .xml file. More than one <path> may be included within the <object> tag, in which case a single <path> is chosen at random for each individual object placement.

heading-type : Indicator of how the heading of the random objects should be determined. Valid values are:

- fixed - Objects all point North. Default.
- random - Objects are assigned an individual random heading
- mask - Rotation is taken from the red channel of the object-mask
- billboard - Object is always rotated to face camera - expensive

## Random Buildings

=====

Random Buildings come in three sizes, with individual constraints.

Small buildings. These have different textures on the sides compared to the front and back. Small buildings are never deeper than they are wide.

Medium buildings, which are never taller than they are wide.

Large buildings. There are no constraints on their width, depth or height.

building-coverage : The coverage of random buildings in areas marked for random objects in m<sup>2</sup>. A lower number means a higher density of buildings. A value of 0 indicates no buildings. May be masked by the blue channel of an object-mask. (default: 0)

building-spacing-m : The minimum spacing between random buildings and other buildings or random objects. This helps avoid objects being placed on top of each other. (default: 5)

building-small-ratio: Ratio of small buildings. These buildings are 1-3 stories in height, and may have a pitched roof. Fraction of small buildings is ( $\langle \text{building-ratio-small} \rangle / (\langle \text{building-ratio-small} \rangle + \langle \text{building-ratio-medium} \rangle + \langle \text{building-ratio-large} \rangle)$ ). (default: 0.8)

building-medium-ratio : Ratio of medium buildings. These buildings are 3-6 stories in height, and have a flat roof. (default: 0.15)

building-large-ratio : Ratio of large buildings. These buildings are 5-10 stories in height, and have a flat roof. (default 0.05)

building-small-pitch : Fraction of small buildings with pitched roofs. (default 0.8)  
building-medium-pitch : Fraction of small buildings with pitched roofs. (default 0.2)  
building-large-pitch : Fraction of small buildings with pitched roofs. (default 0.1)

building-small-min-floors : Min. number of floors for a small building. (default 1)  
building-small-max-floors : Max. number of floors for a small building. (default 3)

building-medium-min-floors : Min. number of floors for a medium building. (default 3)  
building-medium-max-floors : Max. number of floors for a medium building. (default 8)

building-large-min-floors : Min. number of floors for a medium building. (default 5)  
building-large-max-floors : Max. number of floors for a medium building. (default 20)

building-small-min-width-m : Min. width of small buildings. (default 15)  
building-small-max-width-m : Max. width of small buildings. (default 60)  
building-small-min-depth-m : Min. depth of small buildings. (default 10)  
building-small-max-depth-m : Max. depth of small buildings. (default 20)

building-medium-min-width-m : Min. width of medium buildings. (default 25)  
building-medium-max-width-m : Max. width of medium buildings. (default 50)  
building-medium-min-depth-m : Min. depth of medium buildings. (default 20)  
building-medium-max-depth-m : Max. depth of medium buildings. (default 50)

building-large-min-width-m : Min. width of large buildings. (default 50)  
building-large-max-width-m : Max. width of large buildings. (default 75)  
building-large-min-depth-m : Min. depth of large buildings. (default 50)  
building-large-max-depth-m : Max. depth of large buildings. (default 75)

building-texture : The texture used for all buildings. See Docs/buildings.png for details. (default Texture/buildings.png)

building-lightmap: Emissive texture for all buildings, which is faded in at night to provide illusion of lit windows. Same texture coordinates and format at building-texture above.

building-range-m: Range at which all buildings are visible. Beyond this point fewer and fewer buildings are rendered, with no buildings rendered at  $2 \times \text{building-range-m}$  (default 10000)

## 26 Mingw

How to compile FlightGear with mingw  
=====

MinGW & MSYS  
=====

You need to install mingw & msys:

<http://www.mingw.org>

You need at least:

MinGW: binutils, gcc-core, gcc-g++, mingw-runtime, mingw-utils, w32api  
I would recommend the gcc-3.4.4 versions.  
MSYS: msys-1.0.10.exe, msys-autoconf, msys-automake, msys-libtool, msys-DTK.

Please read instructions carefully.

Set the following environment variables within msys shell.

```
export CFLAGS="-I/usr/local/include -O2"
export CXXFLAGS="-I/usr/local/include -O2"
export CPPFLAGS=-I/usr/local/include
export LDFLAGS=-L/usr/local/lib
```

Pthread-win32  
=====

<http://sources.redhat.com/pthreads-win32/>

```
compile:
make GCE-inlined
```

```
Install:
cp pthread.h sched.h semaphore.h /usr/local/include
cp linpthreadGCE2.a /usr/local/lib/libpthread.a
cp pthread-GCE.dll /usr/local/bin
```

patch header:

```
--- pthread.h    Sat Oct  1 20:56:43 2005
*****
*** 210,218 ****
    * -----
    */

! #if HAVE_CONFIG_H
! #include "config.h"
! #endif /* HAVE_CONFIG_H */

! #ifndef NEED_FTIME
! #include <time.h>
--- 210,218 ----
    * -----
    */

! // #if HAVE_CONFIG_H
! // #include "config.h"
! // #endif /* HAVE_CONFIG_H */
```

```
#ifndef NEED_FTIME
#include <time.h>
```

```
GLUT
====
```

use precompiled in order to avoid conflicts with glut32.dll already installed.

```
http://www.xmission.com/~nate/glut.html
http://www.xmission.com/~nate/glut/glut-3.7.6-bin.zip
```

The header has to be updated with respect to MINGW.

```
*** glut.h      Tue Dec 12 22:22:52 2000
--- /local_old/include/GL/glut.h      Thu Aug 18 20:41:15 2005
*****
*** 20,26 ****
    /* XXX This is from Win32's <windef.h> */
    #  ifndef APIENTRY
    #  define GLUT_APIENTRY_DEFINED
! #  if (_MSC_VER >= 800) || defined(_STDCALL_SUPPORTED) || defined(__BORLANDC__) || defined(__LCC__)
    #  define APIENTRY    __stdcall
    #  else
    #  define APIENTRY
--- 20,26 ----
    /* XXX This is from Win32's <windef.h> */
    #  ifndef APIENTRY
    #  define GLUT_APIENTRY_DEFINED
! #  if (_MSC_VER >= 800) || defined(_STDCALL_SUPPORTED) || defined(__BORLANDC__) || defined(__LCC__)
    #  define APIENTRY    __stdcall
    #  else
    #  define APIENTRY
```

```
install:
cp glut.h /usr/local/include
cp glut32.dll /usr/local/bin
```

```
reimp glut32.lib
cp libglut32.a /usr/local/lib
```

```
OpenAL
=====
```

Get OpenAL for instance from Creative

```
OpenAL win32 package
install Redist
```

```
install:

cd libs
reimp OpenAL32.lib
cp libopenal32.a /usr/local/lib
cp alut.lib /usr/local/lib/libalut.a
cd ..
mkdir /usr/local/include/AL
cp Include/* /usr/local/include/AL
```

```
zlib-1.2.3
=====
```

```
configure --prefix=/usr/local
make
make install
```

```
plib-1.6.8
=====
configure --prefix=/usr/local
make
make install
```

```
simgear
=====
get simgear from CVS
configure --prefix=/usr/local
make
make install
```

```
flightgear
=====
configure --prefix=/usr/local --with-threads
make
make install
```

## 27 Minipanel

Mini Panels for c172

List of files:

```
./keyboard.xml - same as release key bindings with "s" added to swap panels.  
./preferences.xml - same as release preferences.xml with "panel2" added.  
./Aircraft/c172/Panels/c172-panel-mini.xml - mini with sacred six, compass,  
mixture knob, flaps, and control indicators.  
./Aircraft/c172/Panels/c172-panel-trans-mini.xml - same mini panel with  
plexiglass (transparent) background.  
./Aircraft/c172/Panels/Textures/panel-mini-bg.rgb - grey background.  
./Aircraft/c172/Panels/Textures/panel-trans-mini-bg.rgb - transparent background.
```

USAGE NOTES:

Hitting "s" will switch between the standard panel and the default.

You may choose other panels for the two that get toggled by changing the preferences or adding command line parameters.

The property for the panels are:

Normal (Primary) panel: /sim/panel/path=<path to xml file>

Mini (Secondary) panel: /sim/panel2/path=<path to xml file>

The new property is /sim/panel2/path, it does not need to be a mini panel, you can use whatever you want.

For example: to use the grey mini panel change preferences.xml or add this to your command line:

```
runfgfs --prop:/sim/panel2/path=Aircraft/c172/Panels/c172-panel-mini.xml
```



## 28 Multiplayer

The commands are of the form:

```
--multiplay=in | out,Hz,destination address,destination port
--callsign=a_unique_name
```

Below are some examples of startup commands that demonstrate the use of the multiplayer facilities.

For two players on a local network or across the internet:

```
-----
Player1:
--multiplay=out,10,192.168.0.3,5500 --multiplay=in,10,192.168.0.2,5501
--callsign=player1
```

```
Player2:
--multiplay=out,10,192.168.0.2,5501 --multiplay=in,10,192.168.0.3,5500
--callsign=player2
```

For multiple players on a local network:

```
-----
Player1:
--multiplay=out,10,255.255.255.255,5500
--multiplay=in,10,255.255.255.255,5500 --callsign=player1
```

```
Playern:
--multiplay=out,10,255.255.255.255,5500
--multiplay=in,10,255.255.255.255,5500 --callsign=playern
```

Note that the callsign is used to identify each player in a multiplayer game so the callsigns must be unique. The multiplayer code ignores packets that are sent back to itself, as would occur with broadcasting when the rx and tx ports are the same.

Multiple players sending to a single player:

```
-----
Player1:
--multiplay=out,10,192.168.0.2,5500 --callsign=player1
```

```
Player2:
--multiplay=out,10,192.168.0.2,5500 --callsign=player2
```

```
Player3:
--multiplay=out,10,192.168.0.2,5500 --callsign=player3
```

```
Player4 (rx only):
--multiplay=in,10,192.168.0.2,5500 --callsign=player4
```

This demonstrates that it is possible to have multiple instances of Flightgear that send to a single instance that displays all the traffic. This is the sort of implementation that we are considering for use as a tower visual simulator.

For use with a server:

```
-----
Oliver Schroeder has created a server for multiplayer flightgear use.
The server acts as a packet forwarding mechanism. When it
receives a packet, it sends it to all other active players
```

in the vicinity (the server is configured to use 100nm by default).

Check out the server homepage <[http://www.o-schroeder.de/fg\\_server/](http://www.o-schroeder.de/fg_server/)> for the current status. You can either download the server for some local use, or join the developers flying at the existing servers. As with flightgear, the server is free software, released under GPL.

Pigeon <<http://pigeond.net>> has created a web page monitoring two such servers, showing the traffic in a Google map environment. See <[http://pigeond.net/flightgear/fg\\_server\\_map.html](http://pigeond.net/flightgear/fg_server_map.html)>.

Options needed to enable multiplayer game with a server:

Player1:

```
--multiplay=out,10,serveraddress,5000 --multiplay=in,10,myaddress,5000
--callsign=player1
```

Player2:

```
--multiplay=out,10,serveraddress,5000 --multiplay=in,10,myaddress,5000
--callsign=player2
```

...

PlayerN:

```
--multiplay=out,10,serveraddress,5000 --multiplay=in,10,myaddress,5000
--callsign=playerN
```

Note that if every player using a particular server, such as one of those listed on the Pigeon's page, needs to have a unique callsign, not already in use on that server.

If you are sitting behind a NAT'ting firewall, then you need to forward the incoming traffic on the firewall outer (visible to the internet) address arriving at the UDP port you use (5000 in the case above) over to your private LAN address. In this case, use your PRIVATE LAN address as <myaddress>. Example (if your private LAN address is 10.0.0.1, in order to play on pigeond.net):

```
fgfs --multiplay=in,10,10.0.0.1,5000 --multiplay=out,10,pigeond.net,5000
    --callsign=...UNIQUE callsign here...
```

If you and the server are in the same address space (i.e., both have a public IP address or both are on the same private LAN), you hopefully don't need to mess with any firewalls.

If you don't see other players playing on the same server in your flightgear, check that you have followed the above router configuration guidelines. Check that you don't have any LOCAL firewall running on your computer preventing the flightgear network traffic flow.

Finally, use ethereal(1) or tethereal(1) to capture the UDP traffic on the port that you are using, and see if you observe both incoming and outgoing packets.

It's a good idea to talk to the IRC channel #flightgear on [irc.flightgear.org](http://irc.flightgear.org) while flying on one of the public servers. Also, it makes sense for every user on the same server to use the same weather setup, e.g., the real weather METAR feed, selected by setting to true the real-world-weather-fetch and control-fdm-atmosphere properties.

Further reading (a must if you have a problem):

-----

- [1] The flightgear server homepage <<http://fgms.sourceforge.net/>>
- [2] The wiki howto <[http://wiki.flightgear.org/index.php/Howto:\\_Multiplayer](http://wiki.flightgear.org/index.php/Howto:_Multiplayer)>
- [3] If everything else fails, ask for help on

the IRC channel #flightgear on [irc.flightgear.org](http://irc.flightgear.org)

## 29 Multiscreen

The Open Scene Graph library, which current FlightGear uses for its 3D graphics, provides excellent support for multiple views of a scene. FlightGear uses the `osgViewer::Viewer` class, which implements a "master" camera with "slave" cameras that are offset from the master's position and orientation. FlightGear provides the "camera group" abstraction which allows the configuration of slave cameras via the property tree.

Slave cameras can be mapped to windows that are open on different screens, or all in one window, or a combination of those two schemes, according to the video hardware capabilities of a machine. It is not advisable to open more than one window on a single graphics card due to the added cost of OpenGL context switching between the windows. Usually, multiple monitors attached to a single graphics card are mapped to different pieces of the same desktop, so a window can be opened that spans all the monitors. This is implemented by Nvidia's TwinView technology and the Matrox TripleHead2Go hardware.

The camera group is configured by the `/sim/rendering/camera-group` node in the property tree. It can be set up by, among other things, XML in `preferences.xml` or in an XML file specified on the command line with the `--config` option.

Here are the XML tags for defining camera groups.

### camera-group

For the moment there can be only one camera group. It can contain window, camera, or gui tags.

### window

A window defines a graphics window. It can be at the camera-group level or defined within a camera. The window contains these tags:

#### name - string

The name of the window which might be displayed in the window's title bar. It is also used to refer to a previously defined window. A window can contain just a name node, in which case the whole window definition refers to a previously defined window.

#### host-name - string

The name of the host on which the window is opened. Usually this is empty.

#### display - int

The display number on which the window is opened.

#### screen - int

The screen number on which the window is opened.

#### x, y - int

The location on the screen at which the window is opened. This is in the window system coordinates, which usually puts 0,0 at the upper left of the screen XXX check this for Windows.

#### width, height - int

The dimensions of the window.

#### decoration - bool

Whether the window manager should decorate the window.

#### fullscreen - bool

Shorthand for a window that occupies the entire screen with no decoration.

overrideRedirect - bool

Only effective when fullscreen = true.

Provides an extra hint for Gnome-based linux systems that we insist that the full screen window span \*all\* physical displays, not just the current physical display.

camera

The camera node contains viewing parameters.

window

This specifies the window which displays the camera. Either it contains just a name that refers to a previous window definition, or it is a full window definition.

viewport

The viewport positions a camera within a window. It is most useful when several cameras share a window.

x, y - int

The position of the lower left corner of the viewport, in y-up coordinates.

width, height - int

The dimensions of the viewport

view

The view node specifies the origin and direction of the camera in relation to the whole camera group. The coordinate system is +y up, -z forward in the direction of the camera group view. This is the same as the OpenGL viewing coordinates.

x,y,z - double

Coordinates of the view origin.

heading-deg, pitch-deg, roll-deg - double

Orientation of the view in degrees. These are specified using the right-hand rule, so a positive heading turns the view to the left, a positive roll rolls the view to the left.

perspective

This node is one way of specifying the viewing volume camera parameters. It corresponds to the OpenGL gluPerspective function.

fovy-deg - double

The vertical field-of-view

aspect-ratio - double

Aspect ratio of camera rectangle (not the ratio between the vertical and horizontal fields of view).

near, far - double

The near and far planes, in meters from the camera eye point. Note that FlightGear assumes that the far plane is far away, currently 120km. The far plane specified here will be respected, but the sky and other background elements may not be drawn if the view plane is closer than 120km.

offset-x, offset-y - double

Offsets of the viewing volume specified by the other parameters in the near plane, in meters.

frustum

This specifies the perspective viewing volume using values for the near and far planes and coordinates of the viewing rectangle in the near plane.

left, bottom - double

right, top - double

The coordinates of the viewing rectangle.

near, far - double

The near and far planes, in meters from the camera eye point.

ortho

This specifies an orthographic view. The parameters are the same as the frustum node's.

gui

This is a special camera node that displays the 2D GUI.

viewport

This specifies the position and dimensions of the GUI within a window, \*however\* at the moment the origin must be at 0,0.

Here's an example that uses a single window mapped across 3 displays. The displays are in a video wall configuration in a horizontal row.

```
<PropertyList>
  <sim>
    <rendering>
      <camera-group>
        <window>
          <name>wide</name>
          <host-name type="string"></host-name>
          <display>0</display>
          <screen>0</screen>
          <width>3840</width>
          <height>1024</height>
          <decoration type = "bool">false</decoration>
        </window>
      <camera>
        <window>
          <name>wide</name>
        </window>
        <viewport>
          <x>0</x>
          <y>0</y>
          <width>1280</width>
          <height>1024</height>
        </viewport>
        <view>
          <heading-deg type = "double">0</heading-deg>
        </view>
        <frustum>
          <top>0.133</top>
          <bottom>-0.133</bottom>
          <left>-.5004</left>
          <right>-.1668</right>
          <near>0.4</near>
          <far>120000.0</far>
        </frustum>
      </camera>
    </rendering>
  </sim>
</PropertyList>
```

```

<camera>
  <window>
    <name type="string">wide</name>
  </window>
  <viewport>
    <x>1280</x>
    <y>0</y>
    <width>1280</width>
    <height>1024</height>
  </viewport>
  <view>
    <heading-deg type = "double">0</heading-deg>
  </view>
  <frustum>
    <top>0.133</top>
    <bottom>-0.133</bottom>
    <left>-.1668</left>
    <right>.1668</right>
    <near>0.4</near>
    <far>120000.0</far>
  </frustum>
</camera>
<camera>
  <window>
    <name>wide</name>
  </window>
  <viewport>
    <x>2560</x>
    <y>0</y>
    <width>1280</width>
    <height>1024</height>
  </viewport>
  <view>
    <heading-deg type = "double">0</heading-deg>
  </view>
  <frustum>
    <top>0.133</top>
    <bottom>-0.133</bottom>
    <left>.1668</left>
    <right>.5004</right>
    <near>0.4</near>
    <far>120000.0</far>
  </frustum>
</camera>
<gui>
  <window>
    <name type="string">wide</name>
  </window>
</gui>
</camera-group>
</rendering>
</sim>
</PropertyList>

```

Here's a complete example that uses a separate window on each display. The displays are arranged in a shallow arc with the left and right displays at a 45.3 degree angle to the center display because, at the assumed screen dimensions, the horizontal field of view of one display is 45.3 degrees. Each camera has its own window definition; the center window is given the name "main" so that the GUI definition can refer to it. Note that the borders of the displays are not accounted for.

```

<PropertyList>
  <sim>
    <rendering>
      <camera-group>
        <camera>
          <window>
            <host-name type="string"></host-name>
            <display>0</display>
            <screen>0</screen>
            <fullscreen type = "bool">true</fullscreen>
          </window>
          <view>
            <heading-deg type = "double">45.3</heading-deg>
          </view>
          <frustum>
            <top>0.133</top>
            <bottom>-0.133</bottom>
            <left>-.1668</left>
            <right>.1668</right>
            <near>0.4</near>
            <far>120000.0</far>
          </frustum>
        </camera>
        <camera>
          <window>
            <name type="string">main</name>
            <host-name type="string"></host-name>
            <display>0</display>
            <screen>1</screen>
            <fullscreen type = "bool">true</fullscreen>
          </window>
          <view>
            <heading-deg type = "double">0</heading-deg>
          </view>
          <frustum>
            <top>0.133</top>
            <bottom>-0.133</bottom>
            <left>-.1668</left>
            <right>.1668</right>
            <near>0.4</near>
            <far>120000.0</far>
          </frustum>
        </camera>
        <camera>
          <window>
            <host-name type="string"></host-name>
            <display>0</display>
            <screen>2</screen>
            <fullscreen type = "bool">true</fullscreen>
          </window>
          <view>
            <heading-deg type = "double">-45.3</heading-deg>
          </view>
          <frustum>
            <top>0.133</top>
            <bottom>-0.133</bottom>
            <left>-.1668</left>
            <right>.1668</right>
            <near>0.4</near>
            <far>120000.0</far>
          </frustum>
        </camera>
      </gui>

```



```
        <window>
          <name type="string">main</name>
        </window>
      </gui>
    </camera-group>
  </rendering>
</sim>
</PropertyList>
```

## 30 Osgtext

This document describes the syntax for text objects in the scene graph. Text nodes are configured using XML and may appear within a model description file, like other models or the particlesystem.

For the anxious reader, here is a complete example of a text node:

```
<!-- Must be enclosed by a <text/> node
<text>
  <!-- It should have a name. Can be used for other animations -->
  <name>My first Text</name>
  <!-- Use offsets for the initial placement -->
  <offsets>
    <pitch-deg>0</pitch-deg>
    <heading-deg>0</heading-deg>
    <roll-deg>0</roll-deg>
    <x-m>0</x-m>
    <y-m>0</y-m>
    <z-m>0</z-m>
  </offsets>

  <!-- instead of using pitch/heading/roll offset, one may use
    axis-alignment -->
  <!-- remember: x backwards, y right and z up -->
  <axis-alignment>xy-plane</axis-alignment>
  <!--
  <axis-alignment>reversed-xy-plane</axis-alignment>
  <axis-alignment>xz-plane</axis-alignment>
  <axis-alignment>reversed-xz-plane</axis-alignment>
  <axis-alignment>yz-plane</axis-alignment>
  <axis-alignment>reversed-yz-plane</axis-alignment>
  <axis-alignment>screen</axis-alignment>
  -->

  <!-- what type of text to draw, use one of literal, text-value or number-value -->
  <!-- A simple constant, never changing string -->
  <type type="string">literal</type>
  <text type="string">Hello, world!</text>

  <!-- The string value of a property -->
  <type type="string">text-value</type>
  <property type="string">some/property</property>
  <format type="string">%s</format> <!-- the printf() format to display the value -->

  <!-- A number from a property -->
  <type type="string">number-value</type>
  <property type="string">position/latitude-deg</property>
  <factor type="double">1.0</factor> <!-- optional, scale the property's value -->
  <offset type="double">0.0</offset> <!-- optional, shift the property's value -->
  <format type="string">%5.2lf</format> <!-- printf() format to display -->
  <truncate type="bool">>false</truncate> <!-- truncate to an integer value -->

  <layout>left-to-right</layout> <!-- default -->
  <!--
  <layout>right-to-left</layout>
  <layout>vertical</layout>
  -->

  <draw-text type="bool">>true</draw-text> <!-- draw the text itself -->
  <draw-alignment type="bool">>false</draw-alignment> <!-- draw crosshair at object center -->
  <draw-boundingbox type="bool">>false</draw-boundingbox> <!-- draw a bounding box -->
```

```

<font>led.ttf</font> <!-- The font file name, relative to data/Fonts -->
<character-size type="double">0.01</character-size> <!-- size (height) in meters -->
<character-aspect-ratio type="double">1.0</character-aspect-ratio>
<max-height>0.012</max-height> <!-- the maximum height of the text -->
<max-width>0.040</max-width> <!-- the maximum width of the text -->
<font-resolution>
  <width type="int">32</width>
  <height type="int">32</height>
</font-resolution>

<!-- chose one of the kerning types or omit for default -->
<kerning>default</kerning>
<!--
<kerning>unfitted</kerning>
<kerning>none</kerning>
-->

<alignment>center-center</alignment> <!-- alignment of the text itself -->
<!-- possible values are
<alignment>left-top</alignment>
<alignment>left-center</alignment>
<alignment>left-bottom</alignment>
<alignment>center-top</alignment>
<alignment>center-center</alignment>
<alignment>center-bottom</alignment>
<alignment>right-top</alignment>
<alignment>right-center</alignment>
<alignment>right-bottom</alignment>
<alignment>left-baseline</alignment>
<alignment>center-baseline</alignment>
<alignment>right-baseline</alignment>
<alignment>baseline</alignment>
-->

</text>

```

The <text/> node may appear within <model/> or <PropertyList/> nodes. If you place your text directly within your model file, use <text></text> nodes. You can also put your <text> configuration into a separate file using the well known include directive:

Your model.xml file:

```

<model>
  <path>may-fancy-model.ac</path>
  <text include="HelloWorld.xml"/>
</model>

```

Your HelloWorld.xml:

```

<PropertyList>
  <name>Hello World</name>
  <font>Helvetica.ttf</font>
  <type type="string">literal</type>
  <text type="string">Hello, world!</text>
  <!-- etc. - you get the idea -->
</PropertyList>

```

Animation can be applied to text nodes like any other object. To give your text some color, use the material animation, or translate, rotate, scale or spin your text as you like.

## 31 Properties

```
=====
CONTROLS
=====

Flight Controls
-----
/controls/flight/aileron
/controls/flight/aileron-trim
/controls/flight/elevator
/controls/flight/elevator-trim
/controls/flight/rudder
/controls/flight/rudder-trim
/controls/flight/flaps
/controls/flight/slats
/controls/flight/BLC // Boundary Layer Control
/controls/flight/spoilers
/controls/flight/speedbrake
/controls/flight/wing-sweep
/controls/flight/wing-fold
/controls/flight/drag-chute

Engines
-----
/controls/engines/throttle_idle
/controls/engines/engine[%d]/throttle
/controls/engines/engine[%d]/starter
/controls/engines/engine[%d]/fuel-pump
/controls/engines/engine[%d]/fire-switch
/controls/engines/engine[%d]/fire-bottle-discharge
/controls/engines/engine[%d]/cutoff
/controls/engines/engine[%d]/mixture
/controls/engines/engine[%d]/propeller-pitch
/controls/engines/engine[%d]/magnetos
/controls/engines/engine[%d]/boost
/controls/engines/engine[%d]/WEP
/controls/engines/engine[%d]/cowl-flaps-norm
/controls/engines/engine[%d]/feather
/controls/engines/engine[%d]/ignition
/controls/engines/engine[%d]/augmentation
/controls/engines/engine[%d]/afterburner
/controls/engines/engine[%d]/reverser
/controls/engines/engine[%d]/water-injection
/controls/engines/engine[%d]/condition

Fuel
----
/controls/fuel/dump-valve
/controls/fuel/tank[%d]/fuel_selector
/controls/fuel/tank[%d]/to_engine
/controls/fuel/tank[%d]/to_tank
/controls/fuel/tank[%d]/boost-pump[%d]

/consumables/fuel/tank[%d]/level-lbs
/consumables/fuel/tank[%d]/level-gal_us
/consumables/fuel/tank[%d]/capacity-gal_us
/consumables/fuel/tank[%d]/density-ppg
/consumables/fuel/total-fuel-lbs
/consumables/fuel/total-gal_us

Gear
```

----

/controls/gear/brake-left  
/controls/gear/brake-right  
/controls/gear/brake-parking  
/controls/gear/steering  
/controls/gear/gear-down  
/controls/gear/antiskid  
/controls/gear/tailhook  
/controls/gear/tailwheel-lock  
/controls/gear/wheel[%d]/alternate-extension

#### Anti-Ice

-----

/controls/anti-ice/wing-heat  
/controls/anti-ice/pitot-heat  
/controls/anti-ice/wiper  
/controls/anti-ice/window-heat  
/controls/anti-ice/engine[%d]/carb-heat  
/controls/anti-ice/engine[%d]/inlet-heat

#### Hydraulics

-----

/controls/hydraulic/system[%d]/engine-pump  
/controls/hydraulic/system[%d]/electric-pump

#### Electric

-----

/controls/electric/battery-switch  
/controls/electric/external-power  
/controls/electric/APU-generator  
/controls/electric/engine[%d]/generator  
/controls/electric/engine[%d]/bus-tie

#### Pneumatic

-----

/controls/pneumatic/APU-bleed  
/controls/pneumatic/engine[%d]/bleed

#### Pressurization

-----

/controls/pressurization/mode  
/controls/pressurization/dump  
/controls/pressurization/outflow-valve  
/controls/pressurization/pack[%d]/pack-on

#### Lights

-----

/controls/lighting/landing-lights  
/controls/lighting/turn-off-lights  
/controls/lighting/formation-lights  
/controls/lighting/taxi-light  
/controls/lighting/logo-lights  
/controls/lighting/nav-lights  
/controls/lighting/beacon  
/controls/lighting/strobe  
/controls/lighting/panel-norm  
/controls/lighting/instruments-norm  
/controls/lighting/dome-norm

#### Armament

-----

/controls/armament/master-arm  
/controls/armament/station-select

```

/controls/armament/release-all
/controls/armament/station[%d]/stick-size
/controls/armament/station[%d]/release-stick
/controls/armament/station[%d]/release-all
/controls/armament/station[%d]/jettison-all

```

#### Seat

```
-----
```

```

/controls/seat/vertical-adjust
/controls/seat/fore-aft-adjust
/controls/seat/cmd_selector_valve
/controls/seat/eject[%d]/initiate
/controls/seat/eject[%d]/status

```

#### APU

```
---
```

```

/controls/APU/off-start-run
/controls/APU/fire-switch

```

#### Autoflight

```
-----
```

```

/controls/autoflight/autopilot[%d]/engage
/controls/autoflight/autothrottle-arm
/controls/autoflight/autothrottle-engage
/controls/autoflight/heading-select
/controls/autoflight/altitude-select
/controls/autoflight/bank-angle-select
/controls/autoflight/vertical-speed-select
/controls/autoflight/speed-select
/controls/autoflight/mach-select
/controls/autoflight/vertical-mode
/controls/autoflight/lateral-mode

```

#### =====

#### FDM (Aircraft settings)

#### =====

#### Position

```
-----
```

```

/position/latitude-deg
/position/longitude-deg
/position/altitude-ft

```

#### Orientation

```
-----
```

```

/orientation/roll-deg
/orientation/pitch-deg
/orientation/heading-deg

```

```

/orientation/roll-rate-degps
/orientation/pitch-rate-degps
/orientation/yaw-rate-degps

```

```

/orientation/side-slip-rad
/orientation/side-slip-deg
/orientation/alpha-deg

```

#### Velocities

```
-----
```

```

/velocities/airspeed-kt
/velocities/mach
/velocities/speed-north-fps
/velocities/speed-east-fps

```

/velocities/speed-down-fps

/velocities/uBody-fps

/velocities/vBody-fps

/velocities/wBody-fps

/velocities/vertical-speed-fps

/velocities/glideslope

## Acceleration

-----

/accelerations/nlf

/accelerations/ned/north-accel-fps\_sec

/accelerations/ned/east-accel-fps\_sec

/accelerations/ned/down-accel-fps\_sec

/accelerations/pilot/x-accel-fps\_sec

/accelerations/pilot/y-accel-fps\_sec

/accelerations/pilot/z-accel-fps\_sec

## Engines

-----

### common:

/engines/engine[%d]/fuel-flow-gph

/engines/engine[%d]/fuel-flow\_pph

/engines/engine[%d]/thrust\_lb

/engines/engine[%d]/running

/engines/engine[%d]/starter

/engines/engine[%d]/cranking

### piston:

/engines/engine[%d]/mp-osi

/engines/engine[%d]/egt-degf

/engines/engine[%d]/oil-temperature-degf

/engines/engine[%d]/oil-pressure-psi

/engines/engine[%d]/cht-degf

/engines/engine[%d]/rpm

### turbine:

/engines/engine[%d]/n1

/engines/engine[%d]/n2

/engines/engine[%d]/epr

/engines/engine[%d]/augmentation

/engines/engine[%d]/water-injection

/engines/engine[%d]/ignition

/engines/engine[%d]/nozzle-pos-norm

/engines/engine[%d]/inlet-pos-norm

/engines/engine[%d]/reversed

/engines/engine[%d]/cutoff

### propeller:

/engines/engine[%d]/rpm

/engines/engine[%d]/pitch

/engines/engine[%d]/torque

## LIGHT

/sim/time/sun-angle-rad

/rendering/scene/ambient/red

/rendering/scene/ambient/ggreen  
/rendering/scene/ambient/blue  
/rendering/scene/diffuse/red  
/rendering/scene/diffuse/green  
/rendering/scene/diffuse/blue  
/rendering/scene/specular/red  
/rendering/scene/specular/green  
/rendering/scene/specular/blue



## 32 Protocol

The generic communication protocol for FlightGear provides a powerful way of adding a simple ASCII based or binary input/output protocol, just by defining an XML encoded configuration file and placing it in the \$FG\_ROOT/Protocol/ directory.

== file layout =====

A protocol file can contain either or both of <input> and <output> definition blocks. Which one is used depends on how the protocol is called (e.g. --generic=file,out,1,/tmp/data.xml,myproto would only use the <output> definitions block).

```
<?xml version="1.0"?>
<PropertyList>
  <generic>

    <output>
      <binary_mode>>false</binary_mode>
      <line_separator></line_separator>
      <var_separator></var_separator>
      <preamble></preamble>
      <postamble></postamble>

      <chunk>
        ... first chunk spec ...
      </chunk>

      <chunk>
        ... another chunk etc. ...
      </chunk>
    </output>

    <input>
      <line_separator></line_separator>
      <var_separator></var_separator>

      <chunk>
        ... chunk spec ...
      </chunk>
    </input>

  </generic>
</PropertyList>
```

== input/output parameters =====

Both <output> and <input> blocks can contain information about the data mode (ascii/binary) and about separators between fields and data sets, as well as a list of <chunk>s. Each <chunk> defines a property that should be written (and how), or a variable and which property it should be written to.

--- ASCII protocol parameters ---

output only:

|             |        |             |                                        |
|-------------|--------|-------------|----------------------------------------|
| <preamble>  | STRING | default: "" | file header put on top of the file     |
| <postamble> | STRING | default: "" | file footer put at the end of the file |

input & output:

|                  |        |                                         |
|------------------|--------|-----------------------------------------|
| <binary_mode>    | BOOL   | default: false (= ASCII mode)           |
| <var_separator>  | STRING | default: "" field separator             |
| <line_separator> | STRING | default: "" separator between data sets |

<var\_separator> are put between every two output properties, while <line\_separator> is put at the end of each data set. Both can contain arbitrary strings or one of the following keywords:

| Name           | Character |
|----------------|-----------|
| newline        | '\n'      |
| tab            | '\t'      |
| formfeed       | '\f'      |
| carriagereturn | '\r'      |
| verticaltab    | '\v'      |

Typical use could be:

```
<var_separator>tab</var_separator>
<line_separator>newline</var_separator>
```

or

```
<var_separator>\t</var_separator>
<line_separator>\r\n</line_separator>
```

--- Binary protocol parameters ---

To enable binary mode, simply include a <binary\_mode>true</binary\_mode> tag in your XML file. The format of the binary output is tightly packed, with 1 byte for bool, 4 bytes for int, and 8 bytes for double. At this time, strings are not supported. A configurable footer at the end of each "line" or packet of binary output can be added using the <binary\_footer> tag. Options include the length of the packet, a magic number to simplify decoding. Examples:

```
<binary_footer>magic,0x12345678</binary_footer>
<binary_footer>length</binary_footer>
<binary_footer>none</binary_footer>          <!-- default -->
```

== variable parameters (chunk spec) =====

Both <input> and <output> block can contain a list of <chunk> specs, each of which describes the properties of on variable to write/read.

|          |                                                          |
|----------|----------------------------------------------------------|
| <name>   | for ease of use (not tranferred)                         |
| <node>   | the property tree node which provides the data           |
| <type>   | the value type (needed for formatting)                   |
|          | one of string, float, bool, int (default: int)           |
| <format> | (ASCII protocol only, not used or needed in binary mode) |
|          | defines the actual piece of text which should be sent.   |
|          | it can include "printf" style formatting options like:   |
|          | <type>                                                   |

```

        %s      string
        %d      integer (default)
        %f      float

```

```

<factor>      an optional multiplication factor which can be used for
                unit conversion. (for example, radians to degrees).
<offset>      an optional offset which can be used for unit conversion.
                (for example, degrees Celcius to degrees Fahrenheit).

```

Chunks can also consist of a single constant <format>, like in:

```

<format>Data Section</format>

```

== examples =====

Writes log of this form:

```

V=16
H=3.590505
P=3.59
V=12
H=3.589020
P=3.59

```

```

<?xml version="1.0"?>

```

```

<PropertyList>
  <generic>

    <output>
      <line_separator>newline</line_separator>
      <var_separator>newline</var_separator>
      <binary_mode>>false</binary_mode>

      <chunk>
        <name>speed</name>
        <format>V=%d</format>
        <node>/velocities/airspeed-kt</node>
      </chunk>

      <chunk>
        <name>heading (rad)</name>
        <format>H=%.6f</format>
        <type>float</type>
        <node>/orientation/heading-deg</node>
        <factor>0.0174532925199433</factor>  <!-- degrees to radians -->
      </chunk>

      <chunk>
        <name>pitch angle (deg)</name>
        <format>P=%03.2f</format>
        <node>/orientation/pitch-deg</node>
      </chunk>
    </output>

  </generic>
</PropertyList>

```

-- writing data in XML syntax -----

Assuming the file is called \$FG\_ROOT/Protocol/xmltest.xml, then it could be used as \$ fgfs --generic=file,out,1,/tmp/data.xml,xmldata

```
<?xml version="1.0"?>
```

```
<PropertyList>
  <generic>
    <output>
      <binary_mode>false</binary_mode>
      <var_separator>\n</var_separator>
      <line_separator>\n</line_separator>
      <preamble>&lt;?xml version="1.0"?&gt;\n\n&lt;data&gt;\n</preamble>
      <postamble>&lt;/data&gt;\n</postamble>

      <chunk>
        <format>\t&lt;set&gt;</format>
      </chunk>

      <chunk>
        <node>/position/altitude-ft</node>
        <type>float</type>
        <format>\t\t&lt;altitude-ft&gt;%.8f&lt;/altitude-ft&gt;</format>
      </chunk>

      <chunk>
        <node>/velocities/airspeed-kt</node>
        <type>float</type>
        <format>\t\t&lt;airspeed-kt&gt;%.8f&lt;/airspeed-kt&gt;</format>
      </chunk>

      <chunk>
        <format>\t&lt;/set&gt;</format>
      </chunk>
    </output>
  </generic>
</PropertyList>
```

-- Analyzing the resulting binary packet format -----

A utility called generic-protocol-analyse can be found under FlightGear/utis/xmlgrep which can be used to analyze the resulting data packet for the binary protocol.

The output would be something like:

bintest.xml

Generic binary output protocol packet description:

| pos | size | type  | factor | description                      |
|-----|------|-------|--------|----------------------------------|
| 0   | 4    | int   |        | indicated speed (kt)             |
| 4   | 4    | float |        | pitch att (deg)                  |
| 8   | 4    | float |        | magnetic heading (deg)           |
| 12  | 4    | int   |        | outside air temperaturure (degF) |
| 16  | 1    | bool  |        | autocoord                        |

total package size: 17 bytes

## 33 Scenery

This document describes how FlightGear searches and loads scenery, how to add static objects to the scenery as well as the syntax of \*.stg files.

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1 scenery path -----

FlightGear loads scenery by default from the Scenery/ subdirectory of its data directory. The path to this data directory can be set via environment variable FG\_ROOT or the --fg-root option. The scenery path can be set independently via environment variable FG\_SCENERY or option --fg-scenery. The order of precedence is as follows:

|                        |                      |
|------------------------|----------------------|
| --fg-scenery=/some/dir | ... highest priority |
| \$FG_SCENERY           |                      |
| \$FG_ROOT/Scenery/     | ... lowest priority  |

A scenery specification may be a list of paths, separated by the OS-specific path separator (colon on Unix/OSX, semicolon on MS Windows). The paths are searched in the order from left to right:

```
FG_SCENERY=/first/dir:/second/dir:/third/dir
                    (likewise with --fg-scenery option)
```

Each of the scenery paths normally contains a set of directories, each containing a particular scenery type :

Terrain/ containing the terrain mesh and airport data  
 Objects/ containing placed scenery objects such as large landmarks, bridges  
 Pylons/ containing electricity pylon Models  
 Roads/ containing detailed road and railways  
 Buildings/ containing osm2city-generated buildings

The user can control at runtime which of these directories is actually loaded via the property tree:

/sim/rendering/scenery-path-suffix[n]/name defines the name of the sub-directory  
 /sim/rendering/scenery-path-suffix[n]/enabled indicates whether it is loaded.

these properties are typically set in the Rendering Options menu.

In turn each of these contains a tree of directories breaking down the world into 10x10 degree and then 1x1 degree chunks. E.g. Terrain/w130n30/w123n37/

For backwards compatibility reasons, the top level can alternatively just contain 10x10 degree directories. E.g. w130n30/w123n37/

Note that as soon as any of the scenery-path-suffix directories is found, any 10x10 directory on the same hierarchy level will be ignored!

This example shows which directories are used to search for scenery:

```
$ ls /first/dir
w130n30/                searched

$ ls /second/dir
Objects/                searched
Terrain/                searched
w130n30/                *not* searched

$ ls /third/dir
Terrain/                searched
w130n30/                *not* searched
```

Within the 1x1 degree chunks, the ground is further broken up into "tiles" of approx 20x20km. If FlightGear searches for a particular "tile" file, let's say for "w130n30/w123n37/942050.stg", then (using the above examples) it looks into

```
/first/dir/w130n30/w123n37/942050.stg      (A)

/second/dir/Terrain/w130n30/w123n37/942050.stg  (B)\__ same path element
/second/dir/Objects/w130n30/w123n37/942050.stg (C)/      /second/dir
/second/dir/Pylons/w130n30/w123n37/942050.stg  (D)/
/second/dir/Roads/w130n30/w123n37/942050.stg   (E)/
/second/dir/Buildings/w130n30/w123n37/942050.stg (F)/

/third/dir/Terrain/w130n30/w123n37/942050.stg  (G)
```

As soon as it finds an OBJECT\_BASE entry it only finishes this path element and then stops scanning. So, if (B) contains an entry "OBJECT\_BASE 942050.btg", then the other directories in /second/dir (C, D, E, F) will be read. But (G) will \*not\*!

This searching behavior is usually used to collect user-downloaded scenery first, then to read automatically downloaded scenery (see terrasync below), then standard scenery and objects that came with the distribution. So a typical scenery path specification could look like this:

```
FG_SCENERY=$HOME/.fgfs/Scenery:$HOME/.fgfs/TerraSync:$FG_ROOT/Scenery
```

The first path would then be populated by the user with unpacked scenery archives downloaded various sources.

Using a private directory for downloaded add-on scenery and adding that path to FG\_SCENERY is the preferred way. This separates default data from locally added data, and makes administration and later updates easier.

HINT: if you want to see where FlightGear is searching and finding terrain/objects, start it with the --log-level=info option.

## 2 terrasync -----

FlightGear can download scenery on-the-fly. Simply select "Download scenery automatically" from the launcher, or use --enable-terrasync from the commandline. By default this will add \$HOME/.fgfs/TerraSync to the scenery path.

Note, however, that if it downloads scenery for the area around your starting location, then you'll only see that after the next start, or after you flew or teleported to a distant location and then back.

### 2.1 .dirindex -----

To save having to download scenery every time, while allowing updates to propagate, terrasync checks for a .dirindex file each time it downloads a directory from the server. This lists files, directories and tarballs that should be present in the local directory, along with their size and a shalsum of their contents. This shalsum is checked against the local files to determine which files are to be downloaded.

The format of the .dirindex is as follows:

```
version:<version>
path:<scenery_path>
<type>:<filename>:<shalsum>:<size>
<type>:<filename>:<shalsum>:<size>
<type>:<filename>:<shalsum>:<size>
.
.
.
```

Where:

<version> is the .dirindex version number  
<scenery\_path> is the path of the current file, e.g. Objects/w010n50/w009n57  
<type> is the file type - "f" for file, "d" for directory, "t" for tarball  
<filename> is the file name (e.g. 2811121.stg)  
<shalsum> is the shalsum of the file named (e.g. 9da6ebc1695ed1c3b151cd34263e9c931ee309ea)  
<size> is the size of the file

Tarballs (labelled with a "t" in the .dirindex) must be <name>.tgz files which unpack into a <name>/ sub-directory. This enables terrasync to clean up out of date files by simply deleting the <name>/ subdirectory before unpacking the updated file.

## 3 stg files -----

stg files ("static terragear") define the static elements of a scenery "tile", including the terrain elevation data, airport geometry, and all static objects placed on this tile. (See section 5 for how to find out which geo coordinates belong to which tile.) Four of the available key words are followed by a string and four numbers. The meaning of these numbers

is always the same and described in section 3.3.

### 3.1 OBJECT\_BASE

specifies the terrain elevation data file. These files are generated with the TerraGear tools (<http://www.terragear.org/>) and have file extension ".btg" ("binary terragear"; there used to be an "\*.atg" file, too, where the 'a' stood for ASCII).

Example:

```
OBJECT_BASE 942050.btg
```

The entry may be anywhere in the 942050.stg file, on a separate line.

### 3.2 OBJECT

specifies an airport geometry 'drop-in' file. The scenery elevation file has cut out holes for airports, that are filled with such objects. They are usually called after the airport ICAO id:

Example:

```
OBJECT KSFO.btg
```

These files are, again, created by TerraGear tools and are usually gzipped, so you'll find that file stored as KSFO.btg.gz.

### 3.3 OBJECT\_SHARED / OBJECT\_SHARED\_AGL

add static object to the tile.

Example:

```
OBJECT_SHARED Models/Airport/tower.xml -122.501090 37.514830 15.5 0.00 0.00 0.00
```

Syntax:

```
OBJECT_SHARED <object-path> <lon> <lat> <elev-m> <hdg-deg> <pitch-deg> <roll-deg>
```

The <object-path> is relative to the data directory (FG\_ROOT).  
<elev-m> is in meter and relative to mean sea-level (in the fgfs world).  
<hdg-deg> is in degree, counter-clockwise with North being 0.0. Note that this differs from about every other place in FlightGear, most notably the /orientation/heading-deg entry in the property system, which is clockwise.  
<pitch-deg> and <roll-deg> are in degree and optional.  
OBJECT\_SHARED models are cached and reused. They are only once in memory and never freed. (See also the next section.)

OBJECT\_SHARED\_AGL places the object relative to the ground elevation. Note that this is an expensive operation and is strongly discouraged.

### 3.4 OBJECT\_STATIC / OBJECT\_STATIC\_AGL

add static objects to the tile, just like OBJECT\_SHARED. There are three differences to OBJECT\_SHARED (apart from the name):



- (A) the path is relative to the tile directory where the \*.stg file with this entry is located. For example, relative to 130n30/w123n37/. This usually means that all 3D object files, textures, and XML animation files are in this tile directory, too.
- (B) these objects are *\*not\** cached and kept loaded, but rather freed with the tile (that is, when you leave that area).
- (C) the animation XML files may contain Nasal blocks <nasal><load> and <nasal><unload> which are executed on loading/unloading.

Example:

```
OBJECT_STATIC ggb-fb.xml -122.4760494 37.81876042 0 105 0.00 0.00
```

OBJECT\_STATIC\_AGL places the object relative to the ground elevation. Note that this is an expensive operation and is strongly discouraged.

### 3.5 OBJECT\_SIGN / OBJECT\_SIGN\_AGL

defines taxiway or runway sign. The syntax is much like that of OBJECT\_SHARED entries, except that the path is replaced with a sign contents specification and that there is an additional size value at the end of the line.

Example:

```
OBJECT_SIGN {@R}10L-28R{@L}C -122.35797457 37.61276290 -0.5398 74.0 2
```

The sign specification defines the sign contents. We try to resemble the apt.dat 850 specifications in our implementation.

In the simplest form it contains just 'normal' text, for example:

```
EXIT
```

This will create a black panel of 1m height with "EXIT" written on it in white versal letters. Actually, each of those characters are single-letter glyph names that are looked up in the <glyph> map of a texture font <material> entry in \$FG\_ROOT/materials.xml. It just happens that the <glyph> entry for <name> 'E' maps to a drawn 'E' in the font texture. This isn't true for all ASCII characters. Many aren't mapped at all (and thus not available), others are mapped to non-standard drawings. The '\_', for example, is mapped to an empty black area and can therefore be used as a space. (The sign specification must not contain real spaces.) The '\*' is mapped to a raised period.

Some glyph names consist of more than one character, and can't, thus, be used directly. They have to be put in a pair of curly braces:

```
{^rd}
```

This creates an arrow that points to the right and down. Braces can really contain a list of glyph names, separated by commas (no space!). Single-letter glyph names can be used that way, too, or in any mixture of both methods:

```
EXIT
{E,X,I,T}
{E}{X}{I}{T}
EX{I,T}
```

```
E{X,I}T{^lu,^rd}
{^u}EXIT{^u}
```

Multi-letter glyph names are usually used for symbols. Arrow symbol names always start with a caret ("arrow head") and the left or right direction always comes first (like the x in a Cartesian coordinate system). Here's a list of some of the available names (see \$FG\_ROOT/materials.xml for more):

```
^l      left arrow
^r      right arrow
^u      up arrow
^d      down arrow
^lu     left-up arrow
^ld     left-down arrow
^ru     right-up arrow
^rd     right-down arrow
no-entry "no entry" symbol
critical runway critical area
safety   ils safety area
hazard   end of taxiway
```

There are commands for pre-defined sign types according to the FAA specification (5345-44; see <http://www.google.com/search?q=5345-44g>).

```
@Y      "Direction, Destination, Boundary" sign (black on yellow)
@R      "Mandatory Instruction" sign (white on red with black outline)
@L      "Location" sign (yellow text and frame on black)
@B      "Runway Distance Remaining" sign (white on black)
```

Examples:

```
{@R}10L-28R{@L}C
{@Y,^l}P|{^lu}N{@L}F{@Y}F{^ru}
{@Y,^ld}C ... same as any of {@Y}{@ld}C {@Y,@ld,C}
{@B}17
```

Syntax errors are reported in --log-level=debug, in the SG\_TERRAIN group. You can use this command line to filter out such messages:

```
$ fgfs --log-level=debug 2>&1|grep OBJECT_SIGN
```

OBJECT\_SIGN\_AGL places the sign relative to the ground elevation. Note that this is an expensive operation and is strongly discouraged.

### 3.6 BUILDING\_ROUGH / BUILDING\_DETAILED

defines building meshes, typically based on OSM data.

Example:

```
BUILDING_ROUGH buildings.ac -122.501090 37.514830 15.5 0.00 0.00 0.00
```

Syntax:

```
BUILDING_ROUGH <object-path> <lon> <lat> <elev-m> <hdg-deg> <pitch-deg> <roll-deg>
```

Note that only bare .ac files should be referenced. The material definition for "OSM\_Building" will be used to determine the texture and Effects.

BUILDING\_ROUGH uses the "rough" LOD range, while BUILDING\_DETAILED uses the "detailed" LOD range. Some randomness is applied so that building meshes gradually fade in

### 3.7 ROAD\_ROUGH / ROAD\_DETAILED

-----

Identical to BUILDING\_ROUGH / BUILDING\_DETAILED above, except used for roads. the material definition "OSM\_Road" is applied.

### 3.8 RAILWAY\_ROUGH / RAILWAY\_DETAILED

-----

Identical to BUILDING\_ROUGH / BUILDING\_DETAILED above, except used for roads. the material definition "OSM\_Railway" is applied.

### 3.9 BUILDING\_LIST

-----

Defines a file containing building coordinates that should be rendered using the building shader (aka Random Buildings).

Example:

```
BUILDING_LIST buildings.txt OSM_Building -2.72943543 56.00080606 36.1
```

Syntax

```
BUILDING_LIST <filename> <material name> <lon> <lat> <elev>
```

Where:

- <filename> is the name of a file containing building positions
- <material name> is the name of the material that will be referenced to find random building parameters.
- <lat>, <lon>, <elev> defines the center of the set of buildings, and also the point at which the material definition will be evaluated (for regional materials).

See README.materials for details on configuring the random building parameters.

The referenced <filename> (in the example buildings.txt) contains lines of the form

```
X Y Z R B W D H P S O F WT RT
```

Where:

- X,Y,Z are the cartesian coordinates of the center of the front face. +X is East, +Y is North
- R is the building rotation in degrees centered on the middle of the front face.
- B is the building type [0, 1, 2] for SMALL, MEDIUM, LARGE
- W is the building width in meters
- D is the building depth in meters
- H is the building height in meters, excluding any pitched roof
- P is the pitch height in meters. 0 for a flat roof
- S is the roof shape (only 0, 2, 4, 6 are implemented, others are approximated to those) :  
0=flat 1=skillion 2=gabled 3=half-hipped 4=hipped 5=pyramidal 6=gambrel  
7=mansard 8=dome 9=onion 10=round 11=saltbox
- O is the roof ridge orientation :  
0 = parallel to the front face of the building  
1 = orthogonal to the front face of the building
- F is the number of floors (integer)

- WT is the texture index to use for walls (integer). Buildings with the same WT value will have the same wall texture.
- RT is the texture index to use for roofs (integer). Buildings with the same RT value will have the same roof texture.

<x> <y> <z> <rot> <type>

where :

- (<x>,<y>,<z>) define the bottom left corner of the building in cartesian space (+X is North, +Y is East, +Z is Up)
- <rot> is the clockwise rotation around the Z-axis in degrees, rotating around the bottom left (SW) corner
- <type> is {0,1,2} which map to small, medium and large buildings respectively, as per random building distribution

For example, the following entries generates 3 small, 2 medium and 2 large buildings in an easterly line:

```
0 0 0 0 0
0 100 0 0 0
0 200 0 0 0
0 300 0 0 1
0 400 0 0 1
0 500 0 0 2
```

4 model manager ("/models/model") -----

#### 4.1 static objects

-----

Another way to add objects to the scenery is via the "model manager". It reads all /models/model entries at startup and places these objects in the scenery. Just load a definition like the following into the property tree, for example by putting it into \$FG\_ROOT/preferences.xml, or better: an XML file that you load with e.g. --config=\$HOME/.fgfs/stuff.xml:

```
<models>
  <model n="0">
    <name>pony</name>
    <path>Local/pony.ac</path>
    <longitude-deg>-115.8352869</longitude-deg>
    <latitude-deg>37.24302849</latitude-deg>
    <elevation-ft>4534.691321</elevation-ft>
    <heading-deg>0</heading-deg>
    <pitch-deg>0</pitch-deg>
    <roll-deg>0</roll-deg>
  </model>
</models>
```

The <path> is relative to \$FG\_ROOT, the <name> is optional. One can leave the heading/pitch/roll entries away, in which case they are set to zero. The values are fixed and unchangeable at runtime.

#### 4.2 dynamic objects

-----

Any of the model properties can be made changeable at runtime by appending "-prop" and using a property path name instead of the fixed value:

```
<local>
  <pony>
    <longitude-deg>-115.8352869</longitude-deg>
    <latitude-deg>37.24302849</latitude-deg>
    <elevation-ft>4534.691321</elevation-ft>
    <heading-deg>0</heading-deg>
```

```

    </pony>
</local>

<models>
  <model n="1">
    <name>pony</name>
    <path>Local/pony.ac</path>
    <longitude-deg-prop>/local/pony/longitude-deg</longitude-deg-prop>
    <latitude-deg-prop>/local/pony/latitude-deg</latitude-deg-prop>
    <elevation-ft-prop>/local/pony/elevation-ft</elevation-ft-prop>
    <heading-deg-prop>/local/pony/heading-deg</heading-deg-prop>
    <pitch-deg>1.234</pitch-deg>  <!-- static, just for fun -->
  </model>
</models>

```

Then one can move the pony around by changing the values in /local/pony/ in the property system. One can, of course, use other animals, too.

#### 4.3 loading/unloading at runtime

-----

Both dynamic and static model-manager-models can be loaded and unloaded at runtime. For loading you first create a new <model> entry under <models>, initialize all properties there (<longitude-deg> or <longitude-deg-prop>, etc.), and finally you create a child <load> of any type in this group. This is the signal for the model manager to load the object. You can remove the <load> property after that. It has no further meaning.

To remove a model-manager model at runtime, you simply delete the whole <model> group.

### 5 tools for object placing -----

#### 5.1 calc-tile.pl

-----

For finding out the tile number for a given geo coordinate pair there's a script "scripts/perl/scenery/calc-tile.pl" in the FlightGear sources. You feed longitude and latitude to it and it returns the path to the \*.stg file where you have to add the object entry.

```

$ perl calc-tile.pl 16.1234 48.5678
Longitude: 16.1234
Latitude:  48.5678
Tile:      3220128
Path:      "e010n40/e016n48/3220128.stg"

```

#### 5.2 ufo scenery object editor

-----

The ufo has a scenery object editor built-in. It uses the model manager described in section 4. To place objects with it, start fgfs, optionally

with specifying an initial model type ("cursor") and a list of subdirectories of \$FG\_ROOT where the ufo should search for available 3D models ("source"):

```
$ fgfs --aircraft=ufo --prop:cursor=Models/Airport/radar.xml \
      --prop:source=Models,Scenery/Objects
```

Then click anywhere on the terrain to add a model (left mouse button). You can open the adjustment dialog (Tab-key) to make adjustments to position and orientation. Click as often as you like, choose further models from the space-key dialog. You can select an already placed object by Ctrl-clicking at its base (not at the object itself, but the surface point where it's located!). By also holding the Shift key down, you can select several objects or add them to a selection. You can remove the selected object(s) with the Backspace-key. (See the ?-key dialog for further available keys.) After clicking on the input field right over the status line (invisible if there's no text in it) you can enter a comment/legend for the selected object.

And finally, you dump the object data to the terminal (d-key) or export them to a file \$HOME/.fgfs/ufo-model-export.xml (Unix) or %APPDATA%\flightgear.org\ufo-model-export.xml (MS Windows).

You can now put the generated object entries into the specified \*.stg file to make them permanent. Or load the whole exported \*.xml file via --config option:

```
$ fgfs --config=$HOME/.fgfs/ufo-model-export.xml
```

If you choose the sign placeholder object from the m-key dialog (first entry; "Aircraft/ufo/Models/sign.ac"), then an OBJEC\_SIGN \*.stg line will be generated with the legend used as sign contents. If you didn't insert any legend, then the sign text will be: NO CONTENTS and a 4 digits random number for later identification in the \*.stg file.

Unfortunately, objects added with this method are kept in memory, no matter where you are actually flying, so the \*.stg method is preferable.

## 6 embedded Nasal in XML files (static objects and AI) -----

### 6.1 static models -----

Objects loaded via OBJECT\_STATIC in \*.stg files as well as AI models loaded via scenarios may contain embedded Nasal code. This can be used to drive more advanced animations. An example is a lighthouse with specific light signals, or hangar doors that open when the "player"'s aircraft is nearby. The Nasal code is added to the object's XML wrapper/animation file, anywhere on the top level, for example:

```
<PropertyList>
  <path>lighthouse.ac</path>

  <nasal>
    <load>
      var loop_id = 0;
      var light = aircraft.light.new("
        /models/static/w120n30/w118n35/lighthouse/light",
```

```

        [2, 1, 2, 1, 2, 1, 2, 5]);

    var loop = func(id) {
        id == loop_id or return;
        light.switch(getprop("/sim/time/sun-angle-rad") > 1.37);
        settimer(func { loop(id) }, 30);
    }
    loop(loop_id += 1);
</load>

<unload>loop_id += 1</unload>
</nasal>

<animation>
    <type>select</type>
    <object-name>light-halo</object-name>
    <property>/models/static/w120n30/w118n35/lighthouse/light/state</property>
</animation>

...
</PropertyList>

```

The <load> part is executed when the scenery tile on which the model is placed is loaded into memory. It can start timers or listeners that modify properties, which are then queried by the <animation>. As a convention developers are requested to use "/models/static/" + <tile-path> + <file-basename>. So, in the above example file "\$FG\_ROOT/Scenery/Objects/w120n30/w118n35/lighthouse.xml" all properties are stored under "/models/static/w120n30/w118n35/lighthouse/". That way collisions with other models are quite unlikely.

An optional <unload> part is executed when the tile and model is removed from memory. Note that this is only when the "player" is already far away! To cause minimal impact on the framerate it is recommended to do as few calculations as possible, to use as large timer intervals as possible, and to stop all timers and listeners in the <unload> part, as shown in the example.

All Nasal variables/functions are in a separate namespace, which is named after the file name. It's recommended not to access this namespace from outside for other than development purposes.

What the above code does: as soon as the model is loaded, an aircraft.light is created with a specific light sequence. Then, in half-minute intervals, the light is turned on or off depending on the sun angle. On <unload> the loop identifier is increased, which makes the loop terminate itself. For more info about this technique, see the Nasal wiki.

## 6.2 AI models

-----

Here the syntax is the same like for static models. The only two differences are:

- these models are currently only removed at program end, so it's more important to consider effects on performance.
- AI models don't need to store their properties in /models/static/..., but get a separate node under /ai/models/, for example /ai/models/carrier[1]. The embedded Nasal code can access this dynamically assigned property via cmdarg() function, which returns a props.Node hash. Example:

```
<nasal>  
  <load>print("my data are under ", cmdarg().getPath())</load>  
  <unload>print("Currently I'm only called at fgfs exit!")</unload>  
</nasal>
```



## 34 Sound

OpenAL setup for general use (Linux)

-----  
As of the July 2004 release of OpenAL it is best to add at least the following line to your ~/.openalrc file on Linux because it will find out what audio backend to use, starting with the most appropriate:

```
(define devices '(native alsa sdl esd arts null))
```

ALSA surround sound (5.1) setup

-----  
(taken from <http://floam.ascorbic.com/how-to/alsa5.1>)

Make a ~/.openalrc, we are telling OpenAL that we want surround sound and we want to use ALSA instead of OSS.

```
(define speaker-num 4)
(define devices '(alsa))
(define alsa-out-device "surround40:0,0")
```

IRIX surround sound (5.1) setup

-----  
To add 4 channel surround sound on IRIX hardware that supports in directly you can just add the following line to your ~/.openalrc file:

```
(define speaker-num 4)
```

To add 4 channel surround sound to IRIX systems that have more than one stereo output you can add the following section to your ~/.openalrc file (for a typical 02 configuration):

```
(define speaker-num 4)
(define native-out-device "Analog Out")
(define native-rear-out-device "Analog Out 2")
```

or alternatively:

```
(define speaker-num 4)
(define native-out-device "A3.Speaker")
(define native-rear-out-device "A3.LineOut2")
```

(Note the following section is obsolete as of the July 2004 release of OpenAL, since you could command OpenAL to use ALSA or Arts directly)

ALSA and Arts

-----  
I'm using kernel 2.6.5 with alsa, my sound module is snd-intel8x0. When I ran fgfs, I'd get quite 'choppy' sound (wasn't smooth, there'd be a couple of breaks in the sound every second or so). Running arts, and starting fgfs with "artsdsp fgfs" (from the artsdsp website: "When an application is run under artsdsp all accesses to the /dev/dsp audio device are intercepted and mapped into aRts API calls. While the device emulation is not perfect, most applications work this way, albeit with some degradation in performance and latency.") would improve the situation, but it seemed to still be choppy.

This command:  
echo "fgfs 0 0 direct" >/proc/asound/card0/pcm0p/oss

(from the alsa kernel OSS emulation website:

"The direct option is used, as mentioned above, to bypass the automatic conversion and useful for MMAP-applications")

made my sound work beautifully when fgfs was run with artsdsp. Running without artsdsp however (with artsd suspended or killed), would give me no sound at all (which I find a bit strange)

The following websites might help people with similar troubles:

<http://www.alsa-project.org/~iwai/OSS-Emulation.html>

<http://www.arts-project.org/doc/handbook/artsdsp.html>

Computer info:

kernel 2.6.5

flightgear 0.9.4

simgear 0.3.5

plib 1.8.3

soundcard is onboard an asus p4p800-e deluxe mobo (using snd-intel8x0), alsa, related modules from lsmod:

| Module          | Size  | Used by                                                                                                                      |
|-----------------|-------|------------------------------------------------------------------------------------------------------------------------------|
| snd_pcm_oss     | 53252 | 1                                                                                                                            |
| snd_mixer_oss   | 19968 | 1 snd_pcm_oss                                                                                                                |
| snd_intel8x0    | 33476 | 1                                                                                                                            |
| snd_ac97_codec  | 63492 | 1 snd_intel8x0                                                                                                               |
| snd_pcm         | 97408 | 2 snd_pcm_oss,snd_intel8x0                                                                                                   |
| snd_timer       | 26112 | 1 snd_pcm                                                                                                                    |
| snd_page_alloc  | 11396 | 2 snd_intel8x0,snd_pcm                                                                                                       |
| snd_mpu401_uart | 7936  | 1 snd_intel8x0                                                                                                               |
| snd_rawmidi     | 24832 | 1 snd_mpu401_uart                                                                                                            |
| snd_seq_device  | 8324  | 1 snd_rawmidi                                                                                                                |
| snd             | 53892 | 9 snd_pcm_oss,snd_mixer_oss,snd_intel8x0,<br>snd_ac97_codec,snd_pcm,snd_timer,snd_mpu401_uart,<br>snd_rawmidi,snd_seq_device |
| soundcore       | 10208 | 2 snd                                                                                                                        |

## 35 Submodels

```
<?xml version="1.0"?>
```

```
<!--
```

Submodels are objects which can be dropped or launched from the user aircraft. The trigger is a boolean property, which you define, which when "true" causes the submodel to be released/launched.

A submodel will create an AIBallistic object which will follow a ballistic path. By default one submodel will be released when the corresponding trigger is "true".

Notes:

1. This utility is intended for ballistic objects which align to the trajectory. Drag is applied based on this assumption: no allowance is for changes in drag for objects which do not conform to this assumption. made
2. While Inertia is calculated properly, Moment of Inertia and rotational aerodynamic damping are simulated. It is assumed that the object is a cylinder of uniform density - if your object does not conform to this, there will be inaccuracies.
3. The program does not calculate windage for ballistic objects well. While adequate for smoke effects, etc., for bullets, bombs, droptanks this is probably best left at "False". Since the effects of wind on various ballistic objects is uncertain, there is no plan to change this situation.
4. Submodels can be nested to any depth, thus a submodel on expiry or impact etc, can launch a child submodel, which in turn can launch a submodel. and so on. This is the basis for Persistent Contrails, but any use is possible.

The initial conditions (IC) define the object's starting point (relative to the user aircraft's "reported position"), and its initial speed and direction (relative to the user aircraft). If you want to release many similar objects with similar IC, then you may use the <repeat>, <delay> and <count> properties to define this. The allowed properties are:

|                |                                                                                                                                                      |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| <name>         | The name of the submodel.                                                                                                                            |
| <model>        | The path to the visual model.                                                                                                                        |
| <trigger>      | The property which will act as the trigger. If this tag is not included, the submodels will be released continuously, provided <count> is set to -1. |
| <speed>        | Initial speed, in feet/sec, relative to user aircraft.                                                                                               |
| <speed-prop>   | The property containing the Initial speed, in feet/sec, relative to user aircraft. If this path is found, <speed> will be overwritten.               |
| <repeat>       | Set "true" if you want multiple releases of this submodel.                                                                                           |
| <delay>        | Time, in seconds, between repeated releases.                                                                                                         |
| <count>        | Number of submodels available for multiple release.<br>-1 defines an unlimited number.                                                               |
| <slaved>       | If true, the submodel is slaved to the parent model.                                                                                                 |
| <x-offset>     | Submodel's initial fore/aft position (in feet), relative to user aircraft. Fore is positive.                                                         |
| <y-offset>     | Submodel's initial left/right position (in feet), relative to user aircraft. Right is positive.                                                      |
| <z-offset>     | Submodel's initial up/down position (in feet), relative to user aircraft. Up is positive.                                                            |
| <yaw-offset>   | Submodel's initial azimuth, in degrees, relative to user aircraft's nose. Right is positive.                                                         |
| <pitch-offset> | Submodel's initial elevation, in degrees, relative to user aircraft's pitch. Up is positive.                                                         |

<life> Life span in seconds.  
 Default is 900.0.  
 <buoyancy> In ft/sec/sec. Works opposite acceleration of gravity.  
 For example, if set to 32 the submodel will feel no gravity. If greater than 32 the object will rise.  
 Default is 0.  
 <wind> Set to true if you want the submodel to react to the wind. Default is "false".  
 <cd> The Coefficient of Drag. Varies with submodel shape - 0.295 for a bullet, 0.045 for an airfoil. Enter an appropriate value. Defaults to 0.295.  
 <random> When this is true the Cd is varied by +- 5%. Useful for smoke or contrails.  
 <eda> Effective drag area (sq ft). Usually the cross-sectional area of the submodel normal to the airflow.  
 <weight> The weight of the submodel (lbs). NOT set to 0 on submodel release. You may wish to set this value to 0 by means of key bindings or Nasal script. Defaults to 0.25.  
 <contents> The path to the contents of a submodel. The contents must be in lbs. Intended for use with drop tanks. The property value will be set to 0 on release of the submodel: do not also set to 0 elsewhere e.g. in key bindings. Defaults to 0.  
 <random> Varies CD by +- 10%, initial azimuth by +- 10 degs, and life by <randomness>  
 <randomness> If <random> is true, <randomness> is applied to <life>. 0 > Value < 1 are valid. Defaults to 0.5.  
 <no-roll> If true the submodel does not roll.  
 <impact> If true, the impact location (lat/lon) on the terrain is calculated. The Material (e.g Grass) of the terrain, load resistance, and impact velocity. Altitude agl is calculated.  
 <collision> If true, collisions with other objects is tested. If a collision is detected then the position data are written to the "Report Node".  
 <fuze-range> Used in detecting collisions. The distance in feet between an object and a submodel at which a collision is deemed to have occurred.  
 <expiry> If true, the current position of the submodel is written to the "Report Node" when the submodel life expires.  
 <impact-reports> Defines a "Report Node". When an impact happens, then the path of the submodel will be written to this node. An attached listener function can evaluate the impact properties. If unset, reports go to /ai/models/model-impact.

\*\*\*\*\* experimental \*\*\*\*\*

<external-force> If true the submodel is subjected to an external force  
 <force-path> A string describing the property where the magnitude, azimuth and elevation of the external force are to be found. The following child properties are instantiated:  
     ~/force-lb  
     ~/force-azimuth-deg  
     ~/force-elevation-deg

You will have to set these values by some means (Nasal script etc.) to make use of this utility.

<PropertyList>

```

<submodel>
  <name>left gun</name>
  <model>Models/Geometry/tracer.ac</model>
  <trigger>ai/submodels/submodel[0]/trigger</trigger>
  <speed>2750.0</speed>
  <repeat>true</repeat>
  <delay>0.25</delay>

```

```

    <count>100</count>
    <x-offset>1.0</x-offset>
    <y-offset>-7.0</y-offset>
    <z-offset>-2.0</z-offset>
    <yaw-offset>0.4</yaw-offset>
    <pitch-offset>1.8</pitch-offset>
    <life>2.0</life>
</submodel>

<submodel>
    <name>right gun</name>
    <model>Models/Geometry/tracer.ac</model>
    <trigger>ai/submodels/submodel[0]/trigger</trigger>
    <speed>2750.0</speed>
    <repeat>true</repeat>
    <delay>0.25</delay>
    <count>100</count>
    <x-offset>1.0</x-offset>
    <y-offset>7.0</y-offset>
    <z-offset>-2.0</z-offset>
    <yaw-offset>-0.4</yaw-offset>
    <pitch-offset>1.8</pitch-offset>
    <life>2.0</life>
</submodel>

<submodel>
    <name>droptank-l</name>
    <model>Aircraft/Hunter/Models/droptank-100gal.ac</model>
    <trigger>controls/armament/station[0]/jettison-all</trigger>
    <speed>0</speed>
    <repeat>false</repeat>
    <count>1</count>
    <x-offset>0.820</x-offset>
    <y-offset>-9.61</y-offset>
    <z-offset>-2.39</z-offset>
    <yaw-offset>0</yaw-offset>
    <pitch-offset>0</pitch-offset>
    <wind>false</wind>
    <eda>2.11348887</eda>
    <weight>170</weight>
    <cd>0.045</cd>
    <contents>consumables/fuel/tank[2]/level-lbs</contents>
</submodel>

<submodel>
    <name>droptank-r</name>
    <model>Aircraft/Hunter/Models/droptank-100gal.ac</model>
    <trigger>controls/armament/station[1]/jettison-all</trigger>
    <speed>0</speed>
    <repeat>false</repeat>
    <count>1</count>
    <x-offset>0.820</x-offset>
    <y-offset>9.61</y-offset>
    <z-offset>-2.39</z-offset>
    <yaw-offset>0</yaw-offset>
    <pitch-offset>0</pitch-offset>
    <wind>false</wind>
    <eda>2.11348887</eda>
    <weight>170</weight>
    <cd>0.045</cd>
    <contents>consumables/fuel/tank[3]/level-lbs</contents>
</submodel>

```

```

<submodel>
  <name>engine exhaust r</name>
  <model>Aircraft/seahawk/Models/exhaust_s.xml</model>
  <trigger>sim/ai/aircraft/exhaust</trigger>
  <speed-node>engines/engine/n1</speed-node>
  <speed>10</speed>
  <repeat>true</repeat>
  <delay>0.1</delay>
  <count>-1</count>
  <x-offset>-3.5</x-offset>
  <y-offset>2.6768</y-offset>
  <z-offset>-0.3937</z-offset>
  <yaw-offset>170</yaw-offset>
  <life>10</life>
  <buoyancy>128</buoyancy>
  <aero-stabilised>0</aero-stabilised>
  <wind>true</wind>
  <eda>1</eda>
  <cd>0.95</cd>
  <weight>1</weight>
  <random>1</random>
</submodel>

</PropertyList>

-->

```

## 36 Systems

By Default systems are initialized by the Aircraft/generic/generic-system.xml

This initializes the following:

- The generic electrical system
- 1 pitot system, index [0]
- 1 static system index [0]
- 2 vacuum systems [0] and [1], depending on engine rpm of engine[0] and engine[1] respectfully

If you want to define more systems, copy the generic-system file to your aircraft-name/Systems folder and rename it systems.xml

In your aircraft -set file add the path to the system.xml file:

```
<sim>
    ....
    <systems>
        ....
        <path>Aircraft/aircraft-name/Systems/systems.xml</path>
        ....
    </systems>
    ....
</sim>
```

**\*\* Adding a second pitot system.**

In your systems.xml, you should already have

```
<pitot>
    <name>pitot</name>
    <number>0</number>
    <stall-deg>60</stall-deg>          # optionnal, default to 60 degrees
</pitot>
```

and you need to add for a pitot system with index 1:

```
<pitot>
    <name>pitot</name>
    <number>1</number>
    <stall-deg>60</stall-deg>  #optionnal
</pitot>
```

For the any pitot system except for the first (with index 0)  
add in the aircraft -set file (below for index 1):

```
<systems>
    <pitot n="1">
        <serviceable>1</serviceable>
    </pitot>
</systems>
```

Of course you can add a third or fourth etc.

**\*\* Adding a second static system**

Absolutely analog with the pitot system. So add in systems.xml:

```
<static>
    <name>static</name>
    <number>1</number>
    <tau>1</tau>
    <type>0</type>          #optionnal: 0,1 or 2 default is 0
    <error-factor>0.5</error-factor>  #optionnal see below default = 0
```

```
</static>
```

and in the aircraft -set file:

```
<systems>
  <static n="1">
    <serviceable>1</serviceable>
  </static>
</systems>
```

Now you can source your instrumentation relying on static and pitot pressure (airspeed, altimeter, vertical speed indicator) from different and independent systems

## **\*\* The PITOT System**

The pitot system measures impact pressure and is basically a tube pointing forward. Small aircraft have one, small IFR aircraft have one or two (of which at least one is heated) and larger commercial aircraft have three or even more. In those large aircraft the left pitot serves the pilot instruments, the right the co-pilot and the third system the back-up instruments. This might be different for each type of aircraft of course.

In Flightgear the pitot system outputs the total pressure to the following property:

```
/systems/pitot[n]/total-pressure-inhg and
/systems/pitot[n]/measured-total-pressure-inhg
```

which are the same except at supersonic speeds. For supersonic aircraft use the "measured" property. See also the README.airspeed-indicator.

However it is advised for every aircraft to use the measured property. In future this will be the property where all the measurement faults are reflected.

the following "measurement failures" are currently applied:

- 1) decrease of total and measured pressure due to side-slip and angle of attack
- 2) at 60 deg the pitot tube will stall and the value will fall back to static pressure
- 3) for the "measured" property only: at Mach>1, a shock wave is assumed in front of the pitot tube, decreasing the total pressure.

The stall angle may be (optionally) set to any angle between 0 and 90 deg (default = 60 deg) like so:

```
<pitot>
  <name>pitot</name>
  <number>0</number>
  <stall-deg>45</stall-deg>
</pitot>
```

Both the decrease of the pitot pressure and the default stall angle are based on a measurement on an AN5812 pitot tube.

## **\*\* The STATIC system**

The static system measures the static pressure. So all influences of airspeed are eliminated.

In real life this is however not always easy. Effects from angle of attack, side-slip, flap deflection, gear extension, engine power setting and airspeed are present and for the aircraft designer it is not always easy to find a good position for the static port.

Usually the number of static systems are equal to the number of pitot systems.

In Flightgear there are 3 types of static systems modelled.

Type 0 (default): the perfect sensor. No measurement failures.

Type 1: Dual static ports on the fuselage sides. Side-slip angle influence only. this model the whole p

Type 2: Static port on the pitot tube. Both angle of attack and side-slip influence.

If you want to use type 1 or 2:

```
<static>
  <name>static</name>
  <number>0</number>
```



```
<tau>0.1</tau>
<type>1</type>
<error-factor>0.5</error-factor>
</static>
```

The output property `/systems/static[n]/pressure-inhg` is filtered. Therefore, if you want to see the effect of the measurement failure, "tau" should be 0.1 or smaller.

The "error-factor" should be between 0.2 and 0.7. Setting it to 0 equals a "perfect sensor".

A setting of 1 means the whole (projected on static port face) impact pressure is applied.

This is not realistic as usually there are more than one static pick-up points and so the pressure increase gets "flattened".

## 37 Tutorials

== README.tutorials =====

FlightGear offers a flexible tutorial system, entirely written in the Nasal language. Tutorials can be started and stopped from the "Help" menu. They are defined in XML files. Each of them has to be loaded into /sim/tutorials/ under a separate tutorial[n]/ branch:

```
<sim>
  <tutorials>
    <tutorial include="Tutorials/take-off.xml"/>
    <tutorial include="Tutorials/landing.xml"/>
  </tutorial>
</sim>
```

Alternatively, all tutorials can be defined in one file, with <tutorial> tags around each tutorial. This is then included like so:

```
<sim>
  <tutorials include="foo-tutorials.xml"/>
</sim>
```

Finally, tutorials are automatically generated from any valid checklists on startup. See README.checklists for details.

== TUTORIAL STRUCTURE =====

A tutorial has this structure, where some of the elements are described in detail below:

```
<tutorial>
  <name>...</name>          mandatory; short identifier, also shown in the
                             tutorial selection dialog
  <description>...</description> mandatory; longer description for the dialog
  <audio-dir>...</audio-dir> optional; defines where to load sound samples
  <timeofday>noon</timeofday> optional; defines daytime; any of "dawn",
                             "morning", "noon", "afternoon",
                             "evening", "dusk", "midnight", "real"

  <step-time>                optional; period between each step being executed.
                             Default 5
  <exit-time>                optional; period between exit/abort conditions being
                             checked. Default 1

  <nasal>
    ...                     optional; initial Nasal code; see below
  </nasal>

  <models>
    ...                     optional; scenery objects; see below
  </models>

  <targets>
    ...                     optional; targets; see below
  </targets>

  <presets>
    ...                     optional; initial simulator state; see below
  </presets>
```

|                                                     |                                                                                                                                                                     |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>&lt;init&gt;</code>                           | optional; initial settings; see below                                                                                                                               |
| <code>&lt;set&gt;</code>                            |                                                                                                                                                                     |
| <code>...</code>                                    | optional; property settings; allowed multiple                                                                                                                       |
| <code>&lt;/set&gt;</code>                           | times                                                                                                                                                               |
| <code>&lt;view&gt;</code>                           |                                                                                                                                                                     |
| <code>...</code>                                    | optional; view settings                                                                                                                                             |
| <code>&lt;/view&gt;</code>                          |                                                                                                                                                                     |
| <code>&lt;marker&gt;</code>                         |                                                                                                                                                                     |
| <code>...</code>                                    | optional; marker coordinates                                                                                                                                        |
| <code>&lt;/marker&gt;</code>                        |                                                                                                                                                                     |
| <code>&lt;nasal&gt;</code>                          |                                                                                                                                                                     |
| <code>...</code>                                    | optional; Nasal code                                                                                                                                                |
| <code>&lt;/nasal&gt;</code>                         |                                                                                                                                                                     |
| <code>&lt;/init&gt;</code>                          |                                                                                                                                                                     |
| <br><code>&lt;step&gt;</code>                       | <br>mandatory; well, not really, but if there's not<br>at least one <code>&lt;step&gt;</code> , then the whole tutorial<br>won't do anything; see below for details |
| <br><code>&lt;message&gt;...&lt;/message&gt;</code> | <br>optional; message to be displayed/spoken when<br><code>&lt;step&gt;</code> is entered; allowed multiple times, in<br>which case one is chosen at random         |
| <code>&lt;message-param&gt;</code>                  | optional; allowed up to 4 times.                                                                                                                                    |
| <code>&lt;property&gt;...&lt;/property&gt;</code>   | property to substitute into the <code>&lt;message&gt;</code> string                                                                                                 |
| <code>&lt;/message-param&gt;</code>                 | using <code>sprintf()</code> formatting. E.g. <code>%d</code> , <code>%.2f</code>                                                                                   |
| <br><code>&lt;audio&gt;...&lt;/audio&gt;</code>     | <br>optional; file name of *.wav sample to be played;<br>may be used multiple times (random)                                                                        |
| <code>&lt;set&gt;</code>                            |                                                                                                                                                                     |
| <code>...</code>                                    | optional; allowed several times                                                                                                                                     |
| <code>&lt;/set&gt;</code>                           |                                                                                                                                                                     |
| <code>&lt;view&gt;</code>                           |                                                                                                                                                                     |
| <code>...</code>                                    | optional                                                                                                                                                            |
| <code>&lt;/view&gt;</code>                          |                                                                                                                                                                     |
| <code>&lt;marker&gt;</code>                         |                                                                                                                                                                     |
| <code>...</code>                                    | optional                                                                                                                                                            |
| <code>&lt;/marker&gt;</code>                        |                                                                                                                                                                     |
| <code>&lt;nasal&gt;</code>                          |                                                                                                                                                                     |
| <code>...</code>                                    | optional; Nasal code that is executed when the<br>step is entered                                                                                                   |
| <code>&lt;/nasal&gt;</code>                         |                                                                                                                                                                     |
| <br><code>&lt;wait&gt;10&lt;/wait&gt;</code>        | <br>optional; wait period after initial messages etc.                                                                                                               |
| <br><code>&lt;error&gt;</code>                      | <br>optional; allowed several times                                                                                                                                 |
| <code>&lt;message&gt;..&lt;/message&gt;</code>      | optional; text displayed/spoken                                                                                                                                     |
| <code>&lt;audio&gt;...&lt;/audio&gt;</code>         | optional; name of *.wav sample to be played                                                                                                                         |
| <br><code>&lt;condition&gt;</code>                  | <br>optional, but one should be there to make sense                                                                                                                 |
| <code>...</code>                                    | see <code>\$FG_ROOT/Docs/README.conditions</code>                                                                                                                   |
| <code>&lt;/condition&gt;</code>                     |                                                                                                                                                                     |
| <code>&lt;nasal&gt;</code>                          |                                                                                                                                                                     |
| <code>...</code>                                    | optional; Nasal code that is executed when the<br>error condition was fulfilled                                                                                     |
| <code>&lt;/nasal&gt;</code>                         |                                                                                                                                                                     |
| <code>&lt;/error&gt;</code>                         |                                                                                                                                                                     |
| <br><code>&lt;exit&gt;</code>                       | <br>optional; defines when to leave this <code>&lt;step&gt;</code>                                                                                                  |
| <code>&lt;condition&gt;</code>                      | see <code>\$FG_ROOT/Docs/README.conditions</code>                                                                                                                   |
| <code>...</code>                                    |                                                                                                                                                                     |
| <code>&lt;/condition&gt;</code>                     |                                                                                                                                                                     |

```

    <nasal>
        ... optional; Nasal code that is executed when the
    </nasal> exit condition was met
</exit>
</step>

<end> optional; final settings & actions; see below
    <message>...</message> optional; multiple times (random)
    <audio>...</audio> optional; multiple times (random)
    <set>
        ... optional
    </set>
    <view>
        ... optional
    </view>
    <nasal>
        ... optional
    </nasal>
</end>
</tutorial>

```

After the tutorial has finished initialization, it goes through all <steps>. For each it outputs the <message> or <audio>, optionally sets a <marker> and/or a <view>, then it checks all <error>s and, if an <error><condition> is fulfilled, outputs the respective <error><message>. If none of the <error>s occurred, then it checks if the <exit><condition> is true, and if so, it jumps to the next <step>. Otherwise the current <step> is endlessly repeated. Finally, after all <step>s were processed, the <end> group is executed.

== ELEMENTS =====

-- <nasal> -----

Embedded Nasal is supported on the top level, in <init> in each <step>, in a <step>'s <error> and <exit>, and in <end>. All Nasal runs in a separate namespace \_\_tutorial, so it's possible to define a function in the <init>'s Nasal block, and to use this function in other blocks without prefix. The namespace is preloaded with some functions:

```

next([n=1])      ... to switch n <step>s forward
previous([n=1])  ... to switch n <step>s backwards

say(what [, who="copilot [, delay=0]])
    ... says 'what' with voice 'copilot' after 'delay' seconds

```

A Nasal group looks like this:

```

<nasal>
    <script>

```

```

        say("Hi, I'm the pilot!", "pilot");
    </script>
    <module>__tutorial</module>          optional; preset with __tutorial
</nasal>

```

-- <models> -----

This loads models into the scenery. It can be used to place, for example, a helicopter landing pad at an airport where normally none is, so that the tutorial can train landing. The layout is the following, with <path> being relative to \$FG\_ROOT:

```

<models>
  <model>
    <path>Models/Airport/supacat_winch.ac</path>      mandatory
    <longitude-deg>-122.4950109</longitude-deg>        mandatory
    <latitude-deg>37.51403798</latitude-deg>           mandatory
    <elevation-ft>51</elevation-ft>                   mandatory
    <heading-deg>2.488888979</heading-deg>            optional (default: 0)
    <pitch-deg>0</pitch-deg>                          optional (default: 0)
    <roll-deg>0</roll-deg>                            optional (default: 0)
  </model>

  <model>
    ...
  </model>
</models>

```

The models are only removed before a new tutorial is loaded. Otherwise they remain in the scenery for the whole FlightGear session. They aren't permanently added.

-- <targets> -----

These are simple pairs of longitude/latitude under an arbitrary name (here "hospital" and "helipad"):

```

<targets>
  <hospital>
    <longitude-deg>-122.4950109</longitude-deg>      mandatory
    <latitude-deg>37.51403798</latitude-deg>         mandatory
  </hospital>

  <helipad>
    ...
  </helipad>
</targets>

```

The tutorial system will for each calculate how the user's aircraft is positioned relative to the respective target, and offer the information in this structure:

```

<sim>
  <tutorials>
    <targets>

```

```

        <hospital>
            <direction-deg>12.345</direction-deg>
            <heading-deg>33.333</heading-deg>
            <distance-m>12404.932</distance-m>
            <eta-min>39.2358</eta-min>
        </hospital>

        <helipad>
            ...
        </helipad>
    </targets>
</tutorials>
</sim>

```

Where:

<direction-deg> is an angle between the aircraft's velocity vector and the azimuth to the target. 0 means that the aircraft is moving right towards the target. 10 means that the target is slightly to the right, -90 means that it's exactly left, and -180 or 179.9999 that it's right behind.

<heading-deg> is the absolute heading that the aircraft would currently have to fly with in a straight line to reach the target

<distance-m> is the distance in meters

<eta-min> is the "Estimated Time of Arrival" given the aircraft's current speed towards the target. Positive times mean that the aircraft is getting nearer to the target and can arrive there in this time given the current speed. It will, of course, only arrive there, if <direction-deg> is zero. A negative number means that the aircraft moves away, or in other words: that in this number of minutes it will be away twice as far.

-- <presets> -----

These set the initial simulator state. All properties are optional. The last three entries are to define the position relative to the airport/runway or the longitude/latitude.

```

<presets>
    <airport-id>KHAF</airport-id>
    <on-ground>1</on-ground>
    <runway>12</runway>
    <!--
    <altitude-ft>122.333</altitude-ft>
    <latitude-deg>37.555</latitude-deg>
    <longitude-deg>1000</longitude-deg>
    -->
    <heading-deg>0</heading-deg>
    <airspeed-kt>0</airspeed-kt>
    <glideslope-deg>0</glideslope-deg>
    <offset-azimuth>0</offset-azimuth>
    <offset-distance>0</offset-distance>
</presets>

```

-- <set> -----

<set> groups can be used in <init>, <step>, and <end>. They set a <property> to a given <value> or to the value that a second <property> points to. They can also reset values that were only temporarily changed for the duration of the tutorial. This is desirable for properties that are saved to the aircraft config file or to ~/.fgfs/autosave.xml.

```
<set>
  <property>/foo/bar</property>      set /foo/bar to 123
  <value>123</value>
</set>

<set>
  <property>/foo/bar</property>      set /foo/bar to value of /test
  <property>/test</property>
</set>
```

-- <view> -----

These groups can be used in <init>, <step>, and <end>. They smoothly move the view to a new view position/direction. All parameters are optional. If, for example, only <field-of-view> is set, then the view will only zoom in -- the direction and position will remain the same. This feature is meant for cockpit tutorials, where the pilot's view is directed to some switch or instrument. view-number can be used to switch between different views, i.e. to tower-view, copilot view etc. Default view-number is 0 (captain's view).

```
<view>
  <view-number>0</view-number>      0=captain's view, 1=copilot,...
  <heading-offset-deg>20</heading-offset-deg>  positive is left
  <pitch-offset-deg>-4</pitch-offset-deg>      positive is up
  <roll-offset-deg>0</roll-offset-deg>         positive is roll right
  <x-offset-m>0.2</x-offset-m>               positive is move right
  <y-offset-m>0.2</y-offset-m>               positive is move up
  <z-offset-m>0.2</z-offset-m>               positive is move back
  <field-of-view>55</field-of-view>          default: 55; smaller zooms in
</view>                                     bigger zooms out
```

-- <marker> -----

These are supported in <init>, <step>, and <end>. They show a magenta colored circle at given position (relative to aircraft origin) in given size. See the last section for how to conveniently find the proper coordinates.

```
<marker>
  <x-m>1.3</x-m>                      positive is back
  <y-m>0.3</y-m>                      positive is to the right
  <z-m>0.1</z-m>                      positive is up
  <scale>1.3</scale>                  optional; default: 1
</marker>
```

For this to work, the aircraft model needs to include the tutorial marker model in its animation xml file:

```
<PropertyList>
  <path>lightning-f1a.ac</path>

  <model>
    <path>Aircraft/Generic/marker.xml</path>
  </model>

  ...
</PropertyList>
```

-- <message>/<audio> -----

Groups <step> and <end> can have one or more <message> entries, and one or more <audio> entries. If more are used of a kind, then the tutorial chooses one at random. If <audio> are available, then the contents are interpreted as file name of a \*.wav sample, which is appended to the <audio-dir> path defined at the <tutorial> top level (default: "") and played by the tutorial system. Otherwise the <message> is handed over to the voice system, and synthesized to speech by the Festival speech synthesizer (if installed). In either case the chosen <message> is displayed on top of the screen. Neither <message> nor <audio> are mandatory.

Because one and the same <message> string can be displayed *and* be synthesized, which can be problematic in some cases, there is a way to specify parts for either display *or* voice synthesizer: "{<display part>|<voice part>".

Example:

```
<message>Press the {No1|number one} button!</message>
```

Here, "No1" would be displayed on the screen, but "number one" would be sent to the speech synthesis system. This can also be used to add invisible but audible exclamation marks: "Press the button{!}"

-- <condition> -----

These are explained in detail in \$FG\_ROOT/Docs/README.conditions. Here's just one example:

```
<condition>
  <less-than>
    <property>/foo/bar</property>
    <value>12</value>
  </less-than>
</condition>
```

This condition is true when the value of /foo/bar is less than 12, and false otherwise.



== FINDING MARKER COORDINATES =====

If an aircraft tutorial wants to use the marker, then the aircraft animation file needs to include the marker model (see above). If this is done, then one can use the "marker-adjust" dialog to find the respective <marker> coordinates. Just type this into the "Help->Nasal Console" dialog:

```
tutorial.dialog()
```

Or temporarily add a key binding to the \*-set.xml file:

```
<key n="96">
  <name>Backtick</name>
  <desc>Open marker adjust dialog</desc>
  <binding>
    <command>dialog-show</command>
    <dialog-name>marker-adjust</dialog-name>
  </binding>
</key>
```

The dialog allows to move a red cross around, which has the blinking marker circle in the middle. Note that ctrl- and shift-modifiers modulate the slider movements. Ctrl makes positioning coarser, and shift finer. The [Reset] button moves the marker back to aircraft origin, the [Center] button centers the sliders, and the [Dump] button dumps the marker coordinates to the terminal, for example:

```
<marker>
  <x-m>1.1425</x-m>
  <y-m>0.1994</y-m>
  <z-m>-0.0844</z-m>
  <scale>2.0489</scale>
</marker>
```

This just needs to be copied to the tutorial XML file.

## 38 Wildfire

Cellular Automata based wildfire for FlightGear/CVS

-----  
Copyright (C) 2008 - 2009 Anders Gidenstam

```
* These programs are free software; you can redistribute them and/or modify
* them under the terms of the GNU General Public License as published by
* the Free Software Foundation; either version 2 of the License, or
* (at your option) any later version.
*
* This program is distributed in the hope that it will be useful,
* but WITHOUT ANY WARRANTY; without even the implied warranty of
* MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
* GNU General Public License for more details.
*
* You should have received a copy of the GNU General Public License
* along with this program; if not, write to the Free Software
* Foundation, Inc., 59 Temple Place, Suite 330, Boston, MA 02111-1307 USA
```

Usage

-----

A fire is started by calling `wild_fire.ignite(pos)` where `pos` is a valid `geo.Coord` instance.

Example: starting fires by `ctrl+shift+click`:

Put this Nasal fragment somewhere where it is run at startup.  
(E.g. in a `<nasal>MyStuff<script>...</script></MyStuff></nasal>` block in `preferences.xml`.)

```
setlistener("/sim/signals/click", func {
  if (__kbd.shift.getBoolValue()) {
    if (__kbd.ctrl.getBoolValue()) {
      var click_pos = geo.click_position();
      wildfire.ignite(click_pos);
    }
  }
});
```

Configuration properties

-----

These properties can be set at runtime, in `preferences.xml` or in any other way supported by FlightGear.

```
/environment/wildfire/enabled : bool
  Enables/disables the whole WildFire module.
  On disable the current state is lost. Can be used to reset WildFire.
```

```
/environment/wildfire/share-events : bool
  Enables/disables sending and receiving of fire events over the
  multiplayer network.
```

```
/environment/wildfire/fire-on-crash : bool
  If true a fire will start if the aircraft crashes.
```

```
/environment/wildfire/report-score : bool
  Report the result of fire fighting.
```

```

/environment/wildfire/models/enabled : bool
  Enables/disables rendering of the 3d models.
  (That is, fire, smoke, soot and foam.)

/environment/wildfire/save-on-exit : bool
  If set the current log of Wildfire events is saved in
  ~/.fgfs/Wildfire/fire_log.xml .

/environment/wildfire/restore-on-startup : bool
  If set Wildfire will load and execute the events in
  ~/.fgfs/Wildfire/fire_log.xml . This recreates the fire state
  as it where when the log was saved.
  NOTE: A long event log or one that covers a long period of time will take
  a a lot of time to recreate.
  Storing and reloading of the CA state, as opposed to the event log, is not
  supported yet.

```

## API

---

```

ignite : func (pos, source=1)
  pos      - fire location      : geo.Coord
  source - broadcast event? : {0, 1}

```

Start a fire.

```

resolve_water_drop : func (pos, radius, volume, source=1)
  pos      - drop location      : geo.Coord
  radius - drop radius m      : double
  volume - Not used            : double
  source - broadcast event? : {0, 1}

```

Extinguishes any fires in the cells within r of pos and makes the cells nonflammable.

```

resolve_retardant_drop : func (pos, radius, volume, source=1) {
  pos      - drop location      : geo.Coord
  radius - drop radius m      : double
  volume - Not used            : double
  source - broadcast event? : {0, 1}

```

Identical to resolve\_water\_drop.

```

resolve_foam_drop : func (pos, radius, volume, source=1) {
  pos      - drop location      : geo.Coord
  radius - drop radius m      : double
  volume - Not used            : double
  source - broadcast?          : {0, 1}

```

Extinguishes any fires in the cells within r of pos and makes the cells nonflammable and foamy.

```

load_event_log : func (filename, skip_ahead_until=-1)
  filename      - getprop("/sim/fg-home") ~ "/Wildfire/" ~ filename
  skip_ahead_until - skip from last event to this time : double (epoch)
                  fast forward from skip_ahead_until
                  to current time.
  x < last event - fast forward all the way to current time (use 0).
                  NOTE: Can be VERY time consuming.
  -1            - skip to current time.

```

Loads an event log.

The `skip_ahead_until` argument can be used for synchronizing a restored fire state among multiple players.

```
save_event_log : func (filename)
    filename          - getprop("/sim/fg-home") ~ "/Wildfire/" ~ filename
```

Saves an event log.

```
print_score = func
    Print a summary of the current wildfire state.
```

/Anders

## 39 Xmlhud

Users' Guide to FlightGear Hud configuration  
December 22 2000  
Neetha Girish <neetha@ada.ernet.in>

This document describes the reconfigurable HUD of FlightGear implemented through XML config files. The present reconfigurable HUD code uses most of the code of version 0.6.1 vintage and I have adapted the same to provide a reconfigurable HUD for fgfs. Corrections and additions are welcome.

Some History:

Older versions of FGFS had a hard coded display of HUD. This was a less than ideal state of affairs when it came to using different aircraft Huds. I remember, somewhere in the 0.6.1 HUD code it was written that the HUD code is 'presently' hard coded but ideally should be moved into the aircraft configuration dataset, so that when you choose an aircraft, its HUD loads. This implementation make that possible, all you have to do is to create appropriate 'my\_aircraft.xml' files in the HUD directory and without re-compiling the code you could have 'your\_aircraft' HUD, by choosing that in the .fgfsrc file or as a command line option as described later. Of course, as of now, I have only implemented those HUD instruments in .xml readable form as was available in version 0.7.6 + few more used by ADA, Bangalore for our aircraft carrier take-off/landing simulation studies <[www.flightgear.org/projects/ADA](http://www.flightgear.org/projects/ADA)>. To use the ADA specific reticles/HUD objects, please contact me/ you can figure it out yourself by studying the code. All of them are relevant 'only' if you use the conformal climb/dive ladder, since they are all referenced to it. The rewrite of Hud display code was done using pre and post release v0.7.6 code allowing for configuration of the hud via XML.

The present Configurable Hud implements the entire functionality of fgfs HUD (called default HUD) till this date.

Using Default/Custom Hud:

The default HUD location is \$FG\_ROOT/Huds/Default. \$FG\_ROOT is the place on your filesystem where you installed FG data files. Alternate huds can be specified on the command line or set as the default in the \$HOME/.fgfsrc or \$FG\_ROOT/preferences.xml using a property specification. The command line format is as follows:

```
--prop:/sim/hud/path=Huds/Default/default.xml
```

The path description shown is relative to \$FG\_ROOT. An absolute path may also be used for locations outside \$FG\_ROOT. For the custom Hud the path will be Huds/Custom/default.xml

Hud - Implementation:

All of the hud configuration files are XML-encoded property lists. The root element of each file is always named <PropertyList>. Tags are always found in pairs, with the closing tag having a slash prefixing the tag name, i.e </PropertyList>. The top level panel configuration file is composed of a <name> and zero or more <instruments>. Instruments are used by including a <"unique\_name"> and a <path> to the instruments configuration file. Comments are bracketed with <!-- -->.

### Example Top Level Hud Config

```
<PropertyList>
  <name>Default Aircraft Hud</name>
  <instruments>

    <hudladder>                                <!--unique name -->
      <path>Huds/Instruments/Default/hudladder.xml</path>
    </hudladder>

    <hudcard>
      <path>Huds/Instruments/Default/hudcard.xml</path>
    </hudcard>

    <instrlabel>
      <path>Huds/Instruments/Default/instrlabel.xml</path>
    </instrlabel>

    <fgTBI>
      <path>Huds/Instruments/Default/fgtbi.xml</path>
    </fgTBI>

  </instruments>
</PropertyList>
```

The default location for instrument files is \$FG\_ROOT/Huds/Instruments/Default.  
The location for custom instrument files is \$FG\_ROOT/Huds/Instruments/Custom.  
The location for minimal instrument files is \$FG\_ROOT/Huds/Instruments/Minimal.  
Alternate locations may be specified in the hud configuration, paths  
must be absolute to use files outside \$FG\_ROOT.

### About Instrument Placement:

For the sake of simplicity the FGFS HUD overlay is always 640 x 480 res.  
so all x/y values for instrument placement should fall within these bounds.  
Being an OpenGL program, 0,0 represents the lower left hand corner of the  
screen.

### Instrument Implementation:

Instruments are defined in separate configuration files.  
The Instruments are basically classified into 4 types( Each of them an xml file) :  
The Hud Ladder,  
The Hud Card,  
The Hud Label and  
The Turn Bank Indicator  
.... (Note that that the earlier HUD classes/objects have been retained)  
Newer objects may be instantiated using the above classes, Unless a totally  
new object is required).

The Default as well as the Custom directory have the same (in terms of properties)  
set of configuration files (but with different values to suit the aircraft).

We have a Base class - Hud Instrument Item.  
We derive two more base classes - Instrument Scale and Dual Instrument Item from this.  
(This implementation owes its existence to all those who wrote the HUD code for 0.6.1)

The Hud Instrument Label is an instantiable class derived from Hud Instrument Item -  
for displaying alphanumeric labels (altitude, velocity, Mach no and/or anything else  
as long you have a call back function to pass the value using the property  
'data\_source').

The Hud Card is an instantiable class derived from Instrument scale - for displaying tapes and gauges (single variable display, for displaying aoa, g's, vsi, elevator\_posn, etc.).

The Hud Ladder is an instantiable class derived from Dual Instrument Item - for displaying pitch reference ladder or climb/dive ladder (two variable display, for displaying two types of ladders, the pitch reference ladder or the climb/dive ladder as defined by MIL-1787b).

The fgTBI Instrument is an instantiable class derived from Dual Instrument scale again - for display of Bank angle and Sideslip (two variable display, for display of TSI info, kept different from the two variable ladder object basically because of its totally different draw member function).

Most Hud instruments may be instantiated using above. It is proposed to provide all Hud objects as defined in MIL-STD-1797A, soon.

Here is how you position 'any' object:

```
x ----- x+width
|         |
|         |
y ----- y+height
```

this defines the objects position centered about the centroid of above rectangle in HUD overlay plane (640x480) coordinates with 0,0 at bottom-left corner.

One more, pixels per degree in the ladder class represents the compression factor of the pitch ladder. In case of conformal HUD (climb/dive ladder) it is <640/horizontal\_fov> or <480/vertical\_fov>. In case of pitch reference ladder it is <your\_no\_of\_vertical\_pixels/your\_no\_of\_ladder\_degrees>.

Example of Hud Ladder xml file.

<PropertyList>

<ladders>

<l1>

<name>Pitch Ladder</name> <!-- Name can be Pitch Ladder or Climb/Dive Ladder -->

<x>260</x> <!-- x start -->

<y>150</y> <!-- y start -->

<width>120</width> <!-- x start + width = x end -->

<height>180</height> <!-- y start + height = y end -->

<compression\_factor>2.68</compression\_factor> <!-- Pixels per degree -->

<loadfn>roll</loadfn> <!-- Name of the function to be called, here

get\_roll() is called provision made in Hud.cxx -->

<loadfn1>pitch</loadfn1> <!-- Name of the function to be called, here get\_pitch() is called -->

<span\_units>45.0</span\_units> <!-- Range of the Ladder seen at any instant -->

<division\_units>10.0</division\_units> <!-- Divisions -->

<screen\_hole>70</screen\_hole> <!-- Hole b/w the Ladder Bars -->

<lbl\_pos>0</lbl\_pos> <!-- Label Position to indicate pitch angle on bar -->

<enable\_frl>false</enable\_frl> <!-- To Enable Pitch Reference Symbol (used by us) -->

<enable\_target\_spot>true</enable\_target\_spot> <!-- To Enable Target Spot Symbol (fgfs

<enable\_velocity\_vector>false</enable\_velocity\_vector> <!-- To Enable Velocity Vector Symbol (u

<enable\_drift\_marker>false</enable\_drift\_marker> <!-- To Enable Drift Marker Symbol (used

<enable\_alpha\_bracket>false</enable\_alpha\_bracket> <!-- To Enable Alpha Bracket Symbol (use

<enable\_energy\_marker>false</enable\_energy\_marker> <!-- To Enable Energy Marker Symbol (use

<enable\_climb\_dive\_marker>false</enable\_climb\_dive\_marker> <!-- To Enable Climb/Dive Marker (used b

<enable\_glide\_slope\_marker>false</enable\_glide\_slope\_marker> <!-- To Enable Glide/Slope Marker (tied

<glide\_slope>0.0</glide\_slope> <!-- Glide slope angle (specify the angl

<enable\_energy\_worm>false</enable\_energy\_worm> <!-- To Enable Energy worm (used by us)

```

<enable_waypoint_marker>false</enable_waypoint_marker>      <!-- To Enable Way point Marker (bearing
<working>true</working>                                       <!-- use this to enable or disable whole
</l1>

```

```

</ladders>

```

```

</PropertyList>

```

```

Before you read this, ----- this is tick_top           |
|                                                           |
|                                                           |-----|
| this is cap_right,tick_left  cap_bottom  tick_right
|
-----| this is tick_bottom

```

Example of Hud Card xml file.

```

<PropertyList>

```

```

<cards>

```

```

<c1>
  <name>Gyrocompass</name>
  <x>220</x>
  <y>430</y>
  <width>200</width>
  <height>28</height>
  <loadfn>heading</loadfn>      <!-- Name of the function to be called, here get_Heading() is called -->
  <options>4</options>          <!-- Read Tape Options Below or Hud.hxx file for details -->
  <maxValue>360.0</maxValue>    <!-- Maximum scale value -->
  <minValue>0.0</minValue>      <!-- Minimum Scale Value -->
  <disp_scaling>1.0</disp_scaling> <!-- Multiply by this to get numbers shown on scale -->
  <major_divs>5</major_divs>    <!-- major division marker units -->
  <minor_divs>1</minor_divs>    <!-- minor division marker units -->
  <modulator>360</modulator>    <!-- Its a rose, Roll Over Point -->
  <value_span>25.0</value_span> <!-- Range Shown -->
  <type>tape</type>              <!-- Card type can be "tape" or "gauge" -->
  <tick_bottom>>false</tick_bottom> <!-- Read Ticks and Caps below -->
  <tick_top>>false</tick_top>
  <tick_right>true</tick_right>
  <tick_left>true</tick_left>
  <cap_bottom>true</cap_bottom>
  <cap_top>>false</cap_top>
  <cap_right>>false</cap_right>
  <cap_left>>false</cap_left>
  <marker_offset>0.0</marker_offset> <!-- Read Marker offset below -->
  <enable_pointer>true</enable_pointer> <!-- To draw a pointer -->
  <pointer_type>fixed</pointer_type> <!-- Type of pointer, Fixed or Moving (yet to be implemented) -->
  <working>true</working>
</c1>

```

```

</cards>

```

```

</PropertyList>

```

Tape Options:

```

HUDS_AUTOTICKS    =    0x0001
HUDS_VERT          =    0x0002
HUDS_HORZ          =    0x0000
HUDS_TOP           =    0x0004
HUDS_BOTTOM        =    0x0008
HUDS_LEFT          =    HUDS_TOP

```



```

HUDS_RIGHT      = HUDS_BOTTOM
HUDS_BOTH       = (HUDS_LEFT | HUDS_RIGHT)
HUDS_NOTICKS    = 0x0010
HUDS_ARITHTIC   = 0x0020
HUDS_DECITICS   = 0x0040
HUDS_NOTEXT     = 0x0080
HUDS_LEFT | HUDS_VERT = 0x0006
HUDS_RIGHT | HUDS_VERT = 0x0010
HUDS_TOP | HUDS_NOTEXT = 0x0084
HUDS_BOTTOM | HUDS_NOTEXT = 0x0088
HUDS_VERT | HUDS_LEFT | HUDS_NOTEXT = 0x0086
HUDS_RIGHT | HUDS_VERT | HUDS_NOTEXT = 0x0090

```

For clarity, I repeat, Ticks and Caps :

1. Left Tick ->|\_\_\_\_\_|<- Right Tick  
                   |  
                   v  
                 Bottom Cap

2. Top Cap  
       |  
       v  
       ----  
       |      |

3. Top Tick  
       |  
       v  
       ---  
           |  
           |<- Right Cap  
           |  
       ---  
       |  
       v  
       Bottom Tick

4.                ---  
                   |  
       Left Cap -> |  
                   |  
                   ---

Marker Offset :

To Draw pointer on the scale markings. In the case of a our hud with offset 10.0  
 The pointer is away from the scale and points at the markings.

```

-|                              -
-|                              -
<|                              -<
-|                              -
-|                              -

```

Marker offset = 0.0           Marker offset = 10.0

This should be useful when I implement the fixed tape/moving pointer.

Example of a Label xml file.

```

<PropertyList>

<labels>

  <i1>
    <name>machno</name>
    <x>25</x>
    <y>130</y>
    <width>40</width>
    <height>30</height>
    <data_source>mach</data_source>    <!-- Name of the function to be called, here get_Heading() is called -->
    <label_format>%4.2f</label_format> <!-- The Label Format -->
    <pre_label_string>blank</pre_label_string> <!-- String to be written Pre Label -->
    <post_label_string>NULL</post_label_string> <!-- String to be written Post Label -->
    <scale_data>1.0</scale_data>
    <options>4</options>                <!-- Read Tape options or Hud.hxx -->
    <justification>2</justification>    <!-- Justify the label, 0=LEFT_JUSTIFY, 1=CENTER_JUSTIFY, 2=RIGHT_JUSTIFY -->
    <blinking>0</blinking>              <!-- Yet to be implemented -->
    <working>true</working>
    <latitude>false</latitude>          <!-- True if the label is to display Latitude (special label, display only) -->
    <longitude>false</longitude>        <!-- True if the label is to display Longitude (special label, display only) -->
  </i1>

</labels>

</PropertyList>

```

Example of a Turn Bank Indicator xml file.

```

<PropertyList>

  <tbi>

    <f1>
      <name>fgTBI_Instrument</name>
      <x>290</x>
      <y>45</y>
      <width>60</width>
      <height>10</height>
      <loadfn>roll</loadfn>              <!-- Name of the function to be called, get_roll() is called here. -->
      <loadfn1>sideslip</loadfn1>        <!-- Name of the function to be called, get_sideslip() is called here. -->
      <maxBankAngle>45.0</maxBankAngle> <!-- Maximum Angle of Bank -->
      <maxSlipAngle>5.0</maxSlipAngle>   <!-- Maximum Angle of Slip -->
      <gap_width>5</gap_width>           <!-- Screen Hole -->
      <working>true</working>
    </f1>

  </tbi>

</PropertyList>

```

I have still got to implement dials (as in MIL-STD-1787b).

REMEMBER IF YOU NEED TO INDICATE ANY OTHER PARAMETER ON THE HUD OTHER THAN WHAT IS PROVIDED AS CALLBACK FUNCTIONS (PROPERTY NAMES LISTED BELOW) YOU HAVE TO FIDDLE WITH THE CODE, AS YET. LET ME KNOW AND I SHALL INCLUDE THAT.

```

<loadfn>anzg</loadfn>                  <!-- Here get_anzg() is called -->
<loadfn>heading</loadfn>               <!-- Here get_heading() is called -->
<loadfn>aoa</loadfn>                   <!-- Here get_aoa() is called -->
<loadfn>climb</loadfn>                 <!-- Here get_climb() is called -->

```

|                                  |                                               |
|----------------------------------|-----------------------------------------------|
| <loadfn>altitude</loadfn>        | <!-- Here get_altitude() is called -->        |
| <loadfn>agl</loadfn>             | <!-- Here get_agl() is called -->             |
| <loadfn>speed</loadfn>           | <!-- Here get_speed() is called -->           |
| <loadfn>view_direction</loadfn>  | <!-- Here get_view_direction() is called -->  |
| <loadfn>aileronval</loadfn>      | <!-- Here get_aileronval() is called -->      |
| <loadfn>elevatordval</loadfn>    | <!-- Here get_elevatordval() is called -->    |
| <loadfn>rudderdval</loadfn>      | <!-- Here get_rudderdval() is called -->      |
| <loadfn>throttleval</loadfn>     | <!-- Here get_throttleval() is called -->     |
| <loadfn>aux16</loadfn>           | <!-- Here get_aux16() is called -->           |
| <loadfn>aux17</loadfn>           | <!-- Here get_aux17() is called -->           |
| <loadfn>aux9</loadfn>            | <!-- Here get_aux9() is called -->            |
| <loadfn>aux11</loadfn>           | <!-- Here get_aux11() is called -->           |
| <loadfn>aux12</loadfn>           | <!-- Here get_aux12() is called -->           |
| <loadfn>aux10</loadfn>           | <!-- Here get_aux10() is called -->           |
| <loadfn>aux13</loadfn>           | <!-- Here get_aux13() is called -->           |
| <loadfn>aux14</loadfn>           | <!-- Here get_aux14() is called -->           |
| <loadfn>aux15</loadfn>           | <!-- Here get_aux15() is called -->           |
| <loadfn>aux8</loadfn>            | <!-- Here get_aux8() is called -->            |
| <loadfn>ax</loadfn>              | <!-- Here get_Ax() is called -->              |
| <loadfn>mach</loadfn>            | <!-- Here get_mach() is called -->            |
| <loadfn>framerate</loadfn>       | <!-- Here get_frame_rate() is called -->      |
| <loadfn>fov</loadfn>             | <!-- Here get_fov() is called -->             |
| <loadfn>vfc_tris_culled</loadfn> | <!-- Here get_vfc_tris_culled() is called --> |
| <loadfn>vfc_tris_drawn</loadfn>  | <!-- Here get_vfc_tris_drawn() is called -->  |
| <loadfn>latitude</loadfn>        | <!-- Here get_latitude() is called -->        |
| <loadfn>longitude</loadfn>       | <!-- Here get_longitude() is called -->       |

## 40 Xmlpanel

Users Guide to FlightGear panel configuration  
Version 0.7.7, May 16 2001  
Author: John Check <j4strngs@rockfish.net>

This document is an attempt to describe the configuration of FlightGear flight simulator's aircraft panel display via XML. The information was culled from the fgfs-devel@flightgear.org mailing list and my experiences making alternate panels. Corrections and additions are encouraged.

Some History:

-----  
Older versions of FGFS had a hard coded display of instruments. This was a less than ideal state of affairs due to FGFS ability to use different aircraft models. Being primarily developed on UNIX type systems, a modular approach is taken towards the simulation. To date, most alternatives to the default Cessna 172 aircraft are the product of research institutions interested in the flight characteristics and not cosmetics. The result of this was that one could fly the X-15 or a Boeing 747 but be limited to C172 instrumentation.

A rewrite of the panel display code was done around v0.7.5 by developer David Megginson allowing for configuration of the panel via XML to address this limitation. Some major changes and additions were made during the course of version 0.7.7 necessitating a rewrite and expansion of this document.

About The Property Manager:

-----  
While not absolutely necessary in order to create aircraft panels, some familiarity with the property manager is beneficial.... FlightGear provides a hierarchical representation of all aspects of the state of the running simulation that is known as the property tree. Some properties, such as velocities are read only. Others such as the frequencies to which the navcom radios are tuned or the position of control surfaces can be set by various means. FlightGear can optionally provide an interface to these properties for external applications such as Atlas, the moving map program, or even lowly telnet, via a network socket. Data can even be placed on a serial port and connected to, say a GPS receiver. Aside from its usefulness in a flight training context, being able to manipulate the property tree on a running copy of FG allows for switching components on the fly, a positive boon for panel authors. To see the property tree start FG with the following command line:

```
fgfs --props=socket,bi,5,localhost,5500,tcp
```

Then use telnet to connect to localhost on port 5500. You can browse the tree as you would a filesystem.

XML and the Property Manager:

-----  
Panel instruments interface with the property tree to get/set values as appropriate. Properties for which FG doesn't yet provide a value can be created by simply making them up. Values can be adjusted using the telnet interface allowing for creation and testing of instruments while code to drive them is being developed.

If fact, the XML configuration system allows a user to combine components such as flight data model, aircraft exterior model, heads

up display, and of course control panel. Furthermore, such a preconfigured aircraft.xml can be included into a scenario with specific flight conditions. These can be manually specified or a FG session can be saved and/or edited and reloaded later. Options specified in these files can be overridden on the command line. For example:

```
--prop:/sim/panel/path=Aircraft/c172/Panels/c172-panel.xml
```

passed as an option, would override a panel specified elsewhere. Property tree options all have the same format, specify the node and supply it a value.

The order of precedence for options is thus:

| Source          | Location              | Format               |
|-----------------|-----------------------|----------------------|
| -----           | -----                 | -----                |
| command line    |                       |                      |
| .fgfsrc         | Users home directory. | command line options |
| system.fgfsrc   | \$FG_ROOT             | " " "                |
| preferences.xml | \$FG_ROOT             | XML property list    |

Loading Panels on the fly:

When editing a panel configuration, pressing Shift +F3 will reload the panel. If your changes don't seem to be taking effect, check the console output. It will report the success or failure of the panel reload\*. Editing textures requires restarting FGFS so the new textures can be loaded. Panels can be switched on the fly by setting the /sim/panel/path property value and reloading.

Regarding Window Geometry:

For the sake of simplicity the FGFS window is always considered to be 1024x768 so all x/y values for instrument placement should be relative to these dimensions. Since FG uses OpenGL 0,0 represents the lower left hand corner of the screen. Panels may have a virtual size larger than 1024x768. Vertical scrolling is accomplished with Shift+F5/F6. Horizontal scrolling is via Shift+F7/F8. An offset should be supplied to set the default visible area. It is possible to place items to overlap the 3D viewport.

Panel Architecture:

All of the panel configuration files are XML-encoded\* property lists. The root element of each file is always named <PropertyList>. Tags are almost always found in pairs, with the closing tag having a slash prefixing the tag name, i.e </PropertyList>. The exception is the tag representing an aliased property. In this case a slash is prepended to the closing angle bracket. (see section Aliasing)

The top level panel configuration file is composed of a <name>, a <background> texture and zero or more <instruments>. Earlier versions required instruments to have a unique name and a path specification pointing to the instruments configuration file.

```
[ Paths are relative to $FG_ROOT (the installed location of FGFS data files.) ]
[ Absolute paths may be used. Comments are bracketed with <!-- -->. ]
```

Old style instrument call in top level panel.xml:

```
<clock>          <!-- required "unique_name" -->
```

```

    <path>Aircraft/c172/Instruments/clock.xml</path>
    <x>110</x>      <!-- required horizontal placement -->
    <y>320</y>      <!-- required vertical placement -->
    <w>72</w>       <!-- optional width specification -->
    <h>72</h>       <!-- optional height specification -->
  </clock>

```

The difference between the old and new styles, while subtle, is rather drastic. The old and new methods are indeed incompatible. I cover the old style only to acknowledge the incompatibility. This section will be removed after the next official FGFS release.

New Style Example Top Level Panel Config:

```

-----
<PropertyList>
  <name>Example Panel</name>
  <background>Aircraft/c172/Panels/Textures/panel-bg.rgb</background>
  <w>1024</w>          <!-- virtual width -->
  <h>768</h>          <!-- virtual height -->
  <y-offset>-305</y-offset> <!-- hides the bottom part -->
  <view-height>172</view-height> <!-- amount of overlap between 2D panel
                                and 3D viewport -->

  <instruments>          <!-- from here down is where old and new
                        styles break compatibility -->

    <instrument include="../Instruments/clock.xml">
      <name>Chronometer</name> <!-- currently optional but strongly recommended -->
      <x>150</x>              <!-- required horizontal placement -->
      <y>645</y>              <!-- required vertical placement -->
      <w>72</w>              <!-- optional width specification -->
      <h>72</h>              <!-- optional height specification -->
    </instrument>

  </instruments>

</PropertyList>

```

Indexed Properties

-----

This is a lot to do with the compatibility break so lets get it out of the way. The property manager now assigns incremental indices to repeated properties with the same parent node, so that

```

<PropertyList>
  <x>1</x>
  <x>2</x>
  <x>3</x>
</PropertyList>

```

shows up as

```

/x[0] = 1
/x[1] = 2
/x[2] = 3

```

This means that property files no longer need to make up a separate name for each item in a list of instruments, layers, actions, transformations, or text chunks. In fact, the new panel I/O code now insists that every instrument have the XML element name "instrument", every layer have the name "layer", every text chunk have the name "chunk", every action have the name "action", and every transformation

have the name "transformation" -- this makes the XML more regular (so that it can be created in a DTD-driven tool) and also allows us to include other kinds of information (such as doc strings) in the lists without causing confusion.

Inclusion:

-----

The property manager now supports file inclusion and aliasing. Inclusion means that a node can include another property file as if it were a part of the current file. To clarify how inclusion works, consider the following examples:

If bar.xml contains

```
<PropertyList>
<a>1</a>
<b>
<c>2</c>
</b>
</PropertyList>
```

then the declaration

```
<foo include="../bar.xml">
</foo>
```

is exactly equivalent to

```
<foo>
<a>1</a>
<b>
<c>2</c>
</b>
</foo>
```

However, it is also possible to selectively override properties in the included file. For example, if the declaration were

```
<foo include="../bar.xml">
<a>3</a>
</foo>
```

then the property manager would see

```
<foo>
<a>3</a>
<b>
<c>2</c>
</b>
</foo>
```

with the original 'a' property's value replaced with 3.

This new inclusion feature allows property files to be broken up and reused arbitrarily -- for example, there might be separate cropping property lists for commonly-used textures or layers, to avoid repeating the information in each instrument file.

Aliasing

-----

Properties can now alias other properties, similar to a symbolic link in Unix. When the target property changes value, the new value will

show up in the aliased property as well. For example,

```
<PropertyList>
<foo>3</foo>
<bar alias="/foo"/>
</PropertyList>
```

will look the same to the application as

```
<PropertyList>
<foo>3</foo>
<bar>3</bar>
</PropertyList>
```

except that when foo changes value, bar will change too.

The combination of inclusions and aliases is very powerful, because it allows for parameterized property files. For example, the XML file for the NAVCOM radio can include a parameter subtree at the start, like this:

```
<PropertyList>
<params>
<comm-freq-prop>/radios/comm1/frequencies/selected</comm-freq-prop>
<nav-freq-prop>/radios/nav1/frequencies/selected</comm-freq-prop>
</params>

...

<chunk>
<type>number-value</type>
<property alias="/params/nav-freq-prop"/>
</chunk>

...
</PropertyList>
```

Now, the same instrument file can be used for navcomm1 and navcomm2, for example, simply by overriding the parameters at inclusion:

```
<instrument include="../Instruments/navcomm.xml">
<params>
<comm-freq-prop>/radios/comm1/frequencies/selected</comm-freq-prop>
<nav-freq-prop>/radios/nav1/frequencies/selected</comm-freq-prop>
</params>
</instrument>

<instrument include="../Instruments/navcomm.xml">
<params>
<comm-freq-prop>/radios/comm2/frequencies/selected</comm-freq-prop>
<nav-freq-prop>/radios/nav2/frequencies/selected</comm-freq-prop>
</params>
</instrument>
```

Instrument Architecture:

-----  
Instruments are defined in separate configuration files. An instrument consists of a base width and height, one or more stacked layers, and zero or more actions. Base dimensions are specified as follows:

```
<PropertyList>                                <!-- remember, all xml files start like this -->
<name>Airspeed Indicator</name> <!-- names are good -->
```



```

<w-base>128</w-base>          <!-- required width spec-->
<h-base>128</h-base>          <!-- required height spec-->
<layers>                        <!-- begins layers section -->

```

Height and width can be overridden in the top level panel.xml by specifying <w> and <h>. Transformations are calculated against the base size regardless of the display size. This ensures that instruments remain calibrated

#### Textures:

FG uses red/green/blue/alpha .rgba files for textures. Dimensions for texture files should be power of 2 with a maximum 8:1 aspect ratio. The lowest common denominator for maximum texture size is 256 pixels. This is due to the limitations of certain video accelerators, most notably those with 3Dfx chipset such as the Voodoo2.

#### Instrument Layers\*\*:

The simplest layer is a <texture>. These can be combined in <switch> layers

<texture>

A texture layer looks like this:

```

<layer>                        <!-- creates a layer -->
  <name>face</name>
  <texture>                    <!-- defines it as a texture layer -->
    <path>Aircraft/c172/Instruments/Textures/faces-2.rgb</path>
    <x1>0</x1>                  <!-- lower boundary for texture cropping-->
    <y1>0.51</y1>              <!-- left boundary for texture cropping-->
    <x2>0.49</x2>              <!-- upper boundary for texture cropping-->
    <y2>1.0</y2>              <!-- right boundary for texture cropping-->
  </texture>                   <!-- closing texture tag -->
</layer>                       <!-- closing layer tag -->

```

The texture cropping specification is represented as a decimal. There is a table at the end of this document for converting from pixel coordinates to percentages.

This particular layer, being a gauge face has no transformations applied to it. Layers with that aren't static *must* include <w> and <h> parameters to be visible.

<type> May be either text or switch..

<type>switch</type>

A switch layer is composed of two or more nested layers and will display one of the nested layers based on a boolean property. For a simple example of a switch see  
\$FG\_ROOT/Aircraft/c172/Instruments/brake.xml.

```

<layer>
  <name>Brake light</name>
  <type>switch</type>          <!-- define layer as a switch -->
  <property>/controls/brakes</property> <!-- tie it to a property -->
  <layer1>                     <!-- layer for true state -->
    <name>on</name>            <!-- label to make life easy -->
    <texture>                  <!-- layer1 of switch is a texture layer -->
      <path>Aircraft/c172/Instruments/Textures/brake.rgb</path>
      <x1>0.25</x1>
      <y1>0.0</y1>
      <x2>0.5</x2>
      <y2>0.095</y2>

```

```

</texture>
<w>64</w>                                <!-- required width - layer isn't static -->
<h>24</h>                                <!-- required height - layer isn't static -->
</layer1>                                <!-- close layer1 of switch -->
<layer2>                                <!-- layer for false state -->
  <name>off</name>
  <texture>
    <path>Aircraft/c172/Instruments/Textures/brake.rgb</path>
    <x1>0.0</x1>
    <y1>0.0</y1>
    <x2>0.25</x2>
    <y2>0.095</y2>
  </texture>
  <w>64</w>
  <h>24</h>
</layer2>
</layer>

```

Switches can have more than 2 states. This requires nesting one switch inside another. One could make, for example, a 3 color LED by nesting switch layers.

<type>text</type>

A text layer may be static, as in a label, generated from a property or a combination of both. This example is a switch that contains both static and dynamic text:

```

<layer1>                                <!-- switch layer -->
  <name>display</name>
  <type>text</type>                      <!-- type == text -->
  <point-size>12</point-size>           <!-- font size -->
  <color>                                <!-- specify rgb values to color text -->
    <red>1.0</red>
    <green>0.5</green>
    <blue>0.0</blue>
  </color>                              <!-- close color section -->
  <chunks>                              <!-- sections of text are referred to as chunks -->
    <chunk>                              <!-- first chunk of text -->
      <type>number-value</type>          <!-- value defines it as dynamic -->
      <property>/radios/nav1/dme/distance</property> <!-- ties it to a property -->
      <scale>0.00053995680</scale>      <!-- convert between statute and nautical miles? -->
      <format>%5.1f</format>            <!-- define format -->
    </chunk>
  </chunks>
</layer1>
<layer2>                                <!-- switch layer -->
  <name>display</name>
  <type>text</type>                      <!-- type == text -->
  <point-size>10</point-size>           <!-- font size -->
  <color>                                <!-- specify rgb values to color text -->
    <red>1.0</red>
    <green>0.5</green>
    <blue>0.0</blue>
  </color>                              <!-- close color section -->
  <chunks>                              <!-- sections of text are referred to as chunks -->
    <chunk>                              <!-- first chunk of text -->
      <type>literal</type>              <!-- static text -->
      <text>---.---</text>              <!-- fixed value -->
    </chunk>
  </chunks>
</layer2>

```

## Transformations:

-----

A transformation is a rotation, an x-shift, or a y-shift. Transformations can be static or they can be based on properties. Static rotations are useful for flipping textures horizontally or vertically. Transformations based on properties are useful for driving instrument needles. I.E. rotate the number of degrees equal to the airspeed. X and y shifts are relative to the center of the instrument. Each specified transformation type takes an <offset>. Offsets are relative to the center of the instrument. A shift without an offset has no effect. For example, let's say we have a texture that is a circle. If we use this texture in two layers, one defined as having a size of 128x128 and the second layer is defined as 64x64 and neither is supplied a shift and offset the net result appears as 2 concentric circles.

## About Transformations and Needle Placement:

-----

When describing placement of instrument needles, a transformation offset must be applied to shift the needles fulcrum or else the needle will rotate around it's middle. The offset will be of <type> x-shift or y-shift depending on the orientation of the needle section in the cropped texture.

This example comes from the altimeter.xml

```
<layer>
  <name>long needle (hundreds)</name>  <!-- the altimeter has more than one needle -->
  <texture>
    <path>Aircraft/c172/Instruments/Textures/misc-1.rgb</path>
    <x1>0.8</x1>
    <y1>0.78125</y1>
    <x2>0.8375</x2>
    <y2>1.0</y2>
  </texture>
  <w>8</w>
  <h>56</h>
  <transformations>
    <transformation>
      <!-- begin defining transformations -->
      <!-- start definition of
      transformation that drives the needle -->
      <type>rotation</type>
      <property>/steam/altitude</property>  <!-- bind it to a property -->
      <max>100000.0</max>
      <!-- upper limit of instrument -->
      <scale>0.36</scale>
      <!-- once around == 1000 ft -->
    </transformation>
    <!-- close this transformation -->
    <transformation>
      <!-- shift the fulcrum of the needle -->
      <type>y-shift</type>
      <!-- y-shift relative to needle -->
      <offset>24.0</offset>
      <!-- amount of shift -->
    </transformation>
  </transformations>
</layer>
```

This needles has its origin in the center of the instrument. If the needles fulcrum was towards the edge of the instrument, the transformations to place the pivot point must precede those which drive the needle,

## Interpolation

-----

Non linear transformations are now possible via the use of interpolation tables.

```

<transformation>
...
<interpolation>
<entry>
<ind>0.0</ind>          <!-- raw value -->
<dep>0.0</dep>          <!-- displayed value -->
</entry>
<entry>
<ind>10.0</ind>
<dep>100.0</dep>
</entry>
<entry>
<ind>20.0</ind>
<dep>-5.0</dep>
</entry>
<entry>
<ind>30.0</ind>
<dep>1000.0</dep>
</entry>
</interpolation>
</transformation>

```

Of course, interpolation tables are useful for non-linear stuff, as in the above example, but I kind-of like the idea of using them for pretty much everything, including non-trivial linear movement -- many instrument markings aren't evenly spaced, and the interpolation tables are much nicer than the older min/max/scale/offset stuff and should allow for a more realistic panel without adding a full equation parser to the property manager.

If you want to try this out, look at the `airspeed.xml` file in the base package, and uncomment the interpolation table in it for a very funky, non-linear and totally unreliable airspeed indicator.

#### Actions:

-----

An action is a hotspot on an instrument where something will happen when the user clicks the left or center mouse button. Actions are always tied to properties: they can toggle a boolean property, adjust the value of a numeric property, or swap the values of two properties. The x/y placement for actions specifies the origin of the lower left corner. In the following example the first action sets up a hotspot 32 pixels wide and 16 pixels high. Its lower left corner is placed 96 pixels (relative to the defined base size of the instrument) to the right of the center of the instrument. It is also 32 pixels below the centerline of the instrument. The actual knob texture over which the action is superimposed is 32x32. Omitted here is a second action, bound to the same property, with a positive increment value. This second action is placed to cover the other half of the knob. The result is that clicking on the left half of the knob texture decreases the value and clicking the right half increases the value. Also omitted here is a second pair of actions with the same coordinates but a larger increment value. This second pair is bound to a different mouse button. The net result is that we have both fine and coarse adjustments in the same hotspot, each bound to a different mouse button.

These examples come from the radio stack:

```

<actions>                                <!-- open the actions section -->
  <action>                                <!-- first action -->
    <name>small nav frequency decrease</name>

```

```

<type>adjust</type>
<button>0</button>          <!-- bind it to a mouse button -->
<x>96</x>                    <!-- placement relative to instrument center -->
<y>-32</y>
<w>16</w>                    <!-- size of hotspot -->
<h>32</h>
<property>/radios/nav1/frequencies/standby</property>  <!-- bind to a property -->
<increment>-0.05</increment>  <!-- amount of adjustment per mouse click -->
<min>108.0</min>              <!-- lower range -->
<max>117.95</max>            <!-- upper range -->
<wrap>1</wrap>                <!-- value wraps around when it hits bounds -->
</action>
<action>
  <name>swap nav frequencies</name>
  <type>swap</type>            <!-- define type of action -->
  <button>0</button>
  <x>48</x>
  <y>-32</y>
  <w>32</w>
  <h>32</h>
  <property1>/radios/nav1/frequencies/selected</property1>  <!-- properties to
  <property2>/radios/nav1/frequencies/standby</property2>    toggle between -->
</action>
<action>
  <name>ident volume on/off</name>
  <type>adjust</type>
  <button>1</button>
  <x>40</x>
  <y>-24</y>
  <w>16</w>
  <h>16</h>
  <property>/radios/nav1/ident</property>  <!-- Morse code ID of nav beacons -->
  <increment>1.0</increment>              <!-- the increment equals the max value
                                          so this toggles on/off -->

  <min>0</min>
  <max>1</max>
  <wrap>1</wrap>                          <!-- a shortcut to avoid having separate
                                          actions for on/off -->

</action>
</actions>

```

#### More About Textures:

-----

As previously stated, the usual size instrument texture files in FGFS are 256x256 pixels, red/green/blue/alpha format. However the mechanism for specifying texture cropping coordinates is decimal in nature. When calling a section of a texture file the 0,0 lower left convention is used. There is a pair of x/y coordinates defining which section of the texture to use.

The following table can be used to calculate texture cropping specifications.

# of divisions | width in pixels | decimal specification  
per axis

|     |   |             |           |
|-----|---|-------------|-----------|
| 1   | = | 256 pixels  | 1         |
| 2   | = | 128 pixels, | 0.5       |
| 4   | = | 64 pixels,  | 0.25      |
| 8   | = | 32 pixels,  | 0.125     |
| 16  | = | 16 pixels,  | 0.0625    |
| 32  | = | 8 pixels,   | 0.03125   |
| 64  | = | 4 pixels,   | 0.015625  |
| 128 | = | 2 pixels,   | 0.0078125 |

A common procedure for generating gauge faces is to use a vector graphics package such as xfig, exporting the result as a postscript file. 3D modeling tools may also be used and I prefer them for pretty items such as levers, switches, bezels and so forth. Ideally, the size of the item in the final render should be of proportions that fit into the recommended pixel widths. The resulting files can be imported into a graphics manipulation package such as GIMP, et al for final processing.

How do I get my panels/instruments into the base package?

-----  
Cash bribes always help ;) Seriously though, there are two main considerations. Firstly, original artwork is a major plus since you as the creator can dictate the terms of distribution. All Artwork must have a license compatible with the GPL. Artwork of unverifiable origin is not acceptable. Secondly, texture sizes must meet the lowest common denominator of 256e2 pixels. Artwork from third parties may be acceptable if it meets these criteria.

\* If there are \*any\* XML parsing errors, the panel will fail to load, so it's worth downloading a parser like Expat (<http://www.jclark.com/xml/>) for checking your XML. FlightGear will print the location of errors, but the messages are a little cryptic right now.

\*\* NOTE: There is one built-in layer -- for the mag compass ribbon -- and all other layers are defined in the XML files. In the future, there may also be built-in layers for special things like a weather-radar display or a GPS (though the GPS could be handled with text properties).

## 41 Xmlparticles

Document started 27/01/2008 by Tiago Gusmão  
Updated 02/02/2008 to reflect syntax changes  
Updated 03/02/2008 to add trails (connected particles)

This is a short specification/tutorial to define particle systems in FlightGear using XML

Meaningless example (what i had accumulated due to tests):

```
<particlesystem>
  <name>fuel</name>
<!--      <texture>particle.rgb</texture> -->
  <emissive>>false</emissive>
  <lighting>true</lighting>

  <offsets>
    <x-m>35</x-m>
    <y-m>-0.3</y-m>
    <z-m>0</z-m>
    <!--<pitch-deg>90</pitch-deg>-->
  </offsets>

  <!--<condition>
    <and>
      <equals>
        <property>engines/engine/smoking</property>
        <value>true</value>
      </equals>
      <less-than>
        <property>position/altitude-agl-ft</property>
        <value>12000</value>
      </less-than>
    </and>
  </condition>-->

  <attach>world</attach>

  <placer>
    <type>point</type>
  </placer>

  <shooter>
    <theta-min-deg>84</theta-min-deg>
    <theta-max-deg>86</theta-max-deg>
    <phi-min-deg>-1.5</phi-min-deg>
    <phi-max-deg>1.5</phi-max-deg>
    <speed>
      <value>10</value>
      <spread>2.5</spread>
    </speed>
    <rotation-speed>
      <x-min-deg-sec>0</x-min-deg-sec>
      <y-min-deg-sec>0</y-min-deg-sec>
      <z-min-deg-sec>0</z-min-deg-sec>
      <x-max-deg-sec>0</x-max-deg-sec>
      <y-max-deg-sec>0</y-max-deg-sec>
      <z-max-deg-sec>0</z-max-deg-sec>
    </rotation-speed>
  </shooter>

  <counter>
```

```

    <particles-per-sec>
      <value>1</value>
    </particles-per-sec>
  </counter>

  <align>billboard</align>

  <particle>
    <start>
      <color>
        <red>
          <value>0.9</value>
        </red>
        <green>
          <value>0.09</value>
        </green>
        <blue>
          <value>0.09</value>
        </blue>
        <alpha>
          <value>1.0</value>
        </alpha>
      </color>
      <size>
        <value>0.25</value>
      </size>
    </start>

    <end>
      <color>
        <red>
          <value>1</value>
        </red>
        <green>
          <value>0.1</value>
        </green>
        <blue>
          <value>0.1</value>
        </blue>
        <alpha>
          <value>0.0</value>
        </alpha>
      </color>
      <size>
        <value>4</value>
      </size>
    </end>

    <life-sec>
      <value>10</value>
    </life-sec>

    <mass-kg>0.25</mass-kg>
    <radius-m>0.1</radius-m>
  </particle>

  <program>
    <fluid>air</fluid>
    <gravity type="bool">true</gravity>
    <wind type="bool">true</wind>
  </program>
</particlesystem>

```



Stick this inside any model XML like it was an animation and it should work (notice the condition requires wheel on the ground)

Specification:

Note:

<VALUEORPROP/> means you can either specify a property with factor and offset (result = (prop\*factor)+offset ) in the usual way

<particlesystem> = the base tag  
    <type>string</type> = can be "normal" or "trail", normal is the usual quad particles, trail is a string of connected line shapes by default.  
    <offsets> = this places the source of the particles (the emitter) in relation to the perhaps already offset model (see model-howto.html for details)  
        <x-m>float</x-m>  
        <y-m>float</y-m>  
        <z-m>float</z-m>  
        <pitch-deg>float</pitch-deg>  
        <roll-deg>float</roll-deg>  
        <heading-deg>float</heading-deg>  
    </offsets>  
    <condition> = a typical condition that if not true stops particles from being  
        .... emitted (PPS=0)  
    </condition>  
    <name>string</name> = the name of the particle system (so it can be referenced by normal animations)  
    <attach>string</attach> = can be "world" or "local". "world" means the particles aren't "physically linked" to the model (necessary for use outside moving models), "local" means the opposite (can be used for static objects or inside moving objects)  
    <texture>string</texture> = the texture path relative to the XML file location  
    <emissive>bool</emissive> = self-explanatory  
    <lighting>bool</lighting> = yet to be tested, but seems obvious  
    <align>string</align> = can be "billboard" or "fixed"  
    <placer> = where particles are born  
        <type>string</type> = can be "sector" (inside a circle), "segments"(user-defined segments) and "point" (default)  
        \* <radius-min-m>float</radius-min-m> = only for sector, inner radius at which particles appear  
        \* <radius-max-m>float</radius-max-m> = only for sector, outer radius at which particles appear  
        \* <phi-min-deg>float</phi-min-deg> = only for sector, starting angle of the slide at which particles appear  
        \* <phi-max-deg>float</phi-max-deg> = only for sector, ending angle of the slide at which particles appear  
    <segments> = only for segments, encloses sequential points that form segments  
        <vertex> = specifies one point, put as many as you want  
            <x-m>float</x-m>  
            <y-m>float</y-m>  
            <z-m>float</z-m>  
        </vertex>  
        ....  
        <vertex>  
        ...  
        </vertex>  
    </segments>  
    </placer>  
    <shooter> = the shooter defines the initial velocity vector for your particles  
        \* <theta-min-deg>float</theta-min-deg> = horizontal angle limits of the particle cone  
        \* <theta-max-deg>float</theta-max-deg>

```

* $\langle\phi\text{-min-deg}\rangle\text{float}\langle\phi\text{-min-deg}\rangle$  = vertical angle limits of the particle cone
* $\langle\phi\text{-max-deg}\rangle\text{float}\langle\phi\text{-max-deg}\rangle$  for an illustration of theta/phi see
http://www.cs.clemson.edu/~malloy/courses/3dgames-2007/tutor/web/particles/particles.html
 $\langle\text{speed-mps}\rangle$  = the scalar velocity (meter per second)
 $\langle\text{VALUEORPROP}\rangle$  = see note
* $\langle\text{spread}\rangle$  = the "tolerance" in each direction so values are in the range
    [value-spread, value+spread]
 $\langle\text{speed-mps}\rangle$ 
 $\langle\text{rotation-speed}\rangle$  = the range of initial rotational speed of the particles
    * $\langle\text{x-min-deg-sec}\rangle\text{float}\langle\text{x-min-deg-sec}\rangle$ 
    * $\langle\text{y-min-deg-sec}\rangle\text{float}\langle\text{y-min-deg-sec}\rangle$ 
    * $\langle\text{z-min-deg-sec}\rangle\text{float}\langle\text{z-min-deg-sec}\rangle$ 
    * $\langle\text{x-max-deg-sec}\rangle\text{float}\langle\text{x-max-deg-sec}\rangle$ 
    * $\langle\text{y-max-deg-sec}\rangle\text{float}\langle\text{y-max-deg-sec}\rangle$ 
    * $\langle\text{z-max-deg-sec}\rangle\text{float}\langle\text{z-max-deg-sec}\rangle$ 
 $\langle\text{rotation-speed}\rangle$ 
 $\langle\text{shooter}\rangle$ 
 $\langle\text{counter}\rangle$ 
     $\langle\text{particles-per-sec}\rangle$ 
     $\langle\text{VALUEORPROP}\rangle$  = see note
    * $\langle\text{spread}\rangle$  = the "tolerance" in each direction so values are in the range
        [value-spread, value+spread]
     $\langle\text{particles-per-sec}\rangle$ 
 $\langle\text{counter}\rangle$ 
 $\langle\text{particle}\rangle$  = defines the particle properties
     $\langle\text{start}\rangle$ 
         $\langle\text{color}\rangle$  = initial color (at time of emission)
             $\langle\text{red}\rangle\langle\text{VALUEORPROP}\rangle\langle\text{red}\rangle$  = color component in normalized value [0,1]
             $\langle\text{green}\rangle\langle\text{VALUEORPROP}\rangle\langle\text{green}\rangle$ 
             $\langle\text{blue}\rangle\langle\text{VALUEORPROP}\rangle\langle\text{blue}\rangle$ 
             $\langle\text{alpha}\rangle\langle\text{VALUEORPROP}\rangle\langle\text{alpha}\rangle$ 
         $\langle\text{color}\rangle$ 
         $\langle\text{size}\rangle$  = as above, but for size
             $\langle\text{VALUEORPROP}\rangle$ 
         $\langle\text{size}\rangle$ 
     $\langle\text{start}\rangle$ 
     $\langle\text{end}\rangle$ 
         $\langle\text{color}\rangle$  = final color (at the end of the particle life)
             $\langle\text{red}\rangle\langle\text{VALUEORPROP}\rangle\langle\text{red}\rangle$ 
             $\langle\text{green}\rangle\langle\text{VALUEORPROP}\rangle\langle\text{green}\rangle$ 
             $\langle\text{blue}\rangle\langle\text{VALUEORPROP}\rangle\langle\text{blue}\rangle$ 
             $\langle\text{alpha}\rangle\langle\text{VALUEORPROP}\rangle\langle\text{alpha}\rangle$ 
         $\langle\text{color}\rangle$ 
         $\langle\text{size}\rangle$ 
             $\langle\text{VALUEORPROP}\rangle$ 
         $\langle\text{size}\rangle$ 
     $\langle\text{end}\rangle$ 
    * $\langle\text{life-sec}\rangle$  = the time the particles will be alive, in seconds
         $\langle\text{VALUEORPROP}\rangle$ 
    * $\langle\text{life-sec}\rangle$ 
    * $\langle\text{radius-m}\rangle\text{float}\langle\text{radius-m}\rangle$  = each particles is physically treated as a sphere
        with this radius
    * $\langle\text{mass-kg}\rangle\text{float}\langle\text{mass-kg}\rangle$  = mass in KG
 $\langle\text{particle}\rangle$ 
 $\langle\text{program}\rangle$  = defines external forces acting upon a particle
     $\langle\text{fluid}\rangle\text{string}\langle\text{fluid}\rangle$  = can be "air" or "water"
     $\langle\text{gravity}\rangle\text{bool}\langle\text{gravity}\rangle$  = can be "true" or "false". uses standard gravity
     $\langle\text{wind}\rangle\text{bool}\langle\text{wind}\rangle$  = can be "true" or "false". uses user position wind (not the
        model position, but shouldn't be noticeable, you want to
        disabled it when using local attach)

 $\langle\text{program}\rangle$ 
 $\langle\text{particles}\rangle$ 

```

Remarks:

- \* Don't forget you can use existing animations with particles, so if you want to direct or translate the emitter, just use translate, rotate, spin and so on (other animations might have interesting effects too I guess)
- \* Particle XML should be compatible with plib, as the tags will be ignored (you might get some warning if you attach them to animations though)
- \* Try not to use a lot of particles in a way that fills the screen, that will demand lots of fill rate and hurt FPS
- \* If you don't use any properties nor conditions, your particle system doesn't need to use a callback so it's slightly better on the CPU (mostly useful for static models)
- \* If your particle lifetime is too big you might run out of particles temporarily (still being investigated)
- \* Use mass and size(radius) to adjust the reaction to gravity and wind (mass/size = density)
- \* Although at the moment severe graphical bugs can be seen in the trails, they are usable.
- \* Consider your options correctly! You should consider giving them no initial velocity and most important, no spread, otherwise particles will race and the trail will fold. Start simple (no velocities and forces) and work your way up.

## 42 Xmlsound

Users Guide to FlightGear sound configuration  
Version 0.9.8, October 30, 2005  
Author: Erik Hofman <erik at ehofman dot com>

This document is an attempt to describe the configuration of  
FlightGear flight simulator's aircraft sound in XML.

Sound Architecture:

-----  
All of the sound configuration files are XML-encoded\* property lists.  
The root element of each file is always named <PropertyList>. Tags are  
almost always found in pairs, with the closing tag having a slash  
prefixing the tag name, i.e </PropertyList>. The exception is the tag  
representing an aliased property. In this case a slash is prepended to  
the closing angle bracket. (see section Aliasing)

The top level sound configuration file is composed of a <fx>, a  
<name>, a <path> sound file and zero or more <volume> and/or <pitch>  
definitions.

```
[ Paths are relative to $FG_ROOT (the root of the installed base package .) ]  
[ Absolute paths may be used. Comments are bracketed with <!-- -->.      ]
```

A limited sound configuration file would look something like this:

```
<PropertyList>  
  <fx>  
    <engine>  
      <name>engine</name>  
      <path>Sounds/wasp.wav</path>  
      <mode>looped</mode>  
      <condition>  
        <property>/engines/engine/running</property>  
      </condition>  
      <volume>  
        <property>/engines/engine/mp-osi</property>  
        <factor>0.005</factor>  
        <min>0.15</min>  
        <max>0.5</max>  
        <offset>0.15</offset>  
      </volume>  
      <pitch>  
        <property>/engines/engine/rpm</property>  
        <factor>0.0012</factor>  
        <min>0.3</min>  
        <max>5.0</max>  
        <offset>0.3</offset>  
      </pitch>  
    </engine>  
  </fx>  
</PropertyList>
```

This would define an engine sound event handler for a piston engine driven  
aeroplane. The sound representing the engine is located in \$FG\_ROOT/Sounds  
and is named wasp.wav. The event is started when the property  
/engines/engine/running becomes non zero.

When that happens, the sound will be played looped (see <mode>) until the  
property returns zero again. As you can see the volume is mp-osi dependent,  
and the pitch of the sound depends on the engine rpm.

## Configuration description:

-----

### <fx>

Named FX subtree living under /sim/sound

### < ... >

This is the event separator. The text inside the brackets can be anything. But it is advised to give it a meaningful name like: crank, engine, rumble, gear, squeal, flap, wind or stall

The value can be defined multiple times, thus anything which is related may have the same name (grouping them together).

### <name>

This defines the name of the event. This name is used internally and, although it can be defined multiple times in the same file, should normally have a unique value.

Multiple definitions of the same name will allow multiple sections to interfere in the starting and stopping of the sample.

This method can't be used to control the pitch or volume of the sample, but instead multiple volume or pitch section should be included inside the same event.

The types "raise" and "fall" will stop the playback of the sample regardless of any other event. This means that when the type "raise" is supplied, sample playback will stop when the event turns false. Using the type "fall" will stop playback when the event turns true.

#### IMPORTANT:

If the trigger is used for anything else but stopping the sound at a certain event, all sections with the same name *\*should\** have exactly the same sections for everything but property and type.

In the case of just stopping the sample at a certain event, the sections for path, volume and pitch may be omitted.

### <path>

This defines the path to the sound file. The path is relative to the FlightGear root directory but could be specified absolute.

### <condition>

Define a condition that triggers the event.  
For a complete description of the FlightGear conditions, please read docs-mini/README.conditions

An event should define either a condition or a property.

### <property>

Define which property triggers the event, and refers to a node in the FlightGear property tree. Action is taken when the property is non zero.

A more sophisticated mechanism to trigger the event is described in <condition>

### <mode>

This defines how the sample should be played:

once:                the sample is played once.  
                      this is the default.

looped:           the sample plays continuously,  
                  until the event turns false.

in-transit:       the sample plays continuously,  
                  while the property is changing its value.

#### <type>

This defines the type of this sample:

fx:               this is the default type and doesn't need to be defined.

avionics:        sounds set to this time don't have a position and  
                  orientation but are treated as if it's mounted to  
                  the aircraft panel. it's up to the user to define  
                  if it can always be heard or only when in cockpit  
                  view.

#### <volume> / <pitch>

Volume or Pitch definition. Currently there may be up to 5  
volume and up to 5 pitch definitions defined within one sound  
event.

The volume elements are processed as follows

```
total_offset = 0
total_volume = 1.0
```

for each <volume> element:

- (a) Use either <property> or <internal> as the base value
- (b) apply any <type> function to the value
- (c) value = value \* factor
- (d) value = max(value, <max>)
- (e) value = min(value, <min>)
- (f) if <factor> was originally negative then use  
offset-mode otherwise use normal mode

(normal-mode)

```
total_offset = total_offset + offset
total_volume = total_volume * value
```

(offset-mode)

```
value = value + offset
total_volume = total_volume * value
```

Then after processing all of the <volume> blocks the total  
volume will be determined by

```
volume = total_offset + total_volume;
```

#### <expression>

Defines the AN SGExpression to be used to calculate the volume  
or pitch. When an expression is used all other tags in the  
volume block are ignored.

Refs: README.expressions

<http://wiki.flightgear.org/Expressions>

#### <property>

Property to use for the base value for the calculation.

#### <factor>

Defines the multiplication factor for the property value.

If factor is negative then it will cause the calculation for this element to use the offset-mode as defined above. The negative value for the factor will be converted to positive

#### <offset>

The offset elements will be summed and added to the to the calculated volume from all of the volume blocks, except when using offset-mode in which case the offset is directly added to the calculated volume within each volume block

#### <internal>

Defines which internal variable should be used for the calculation.

The value is treated as a floating point number.

The following internals are available at this time:

dt\_play:           the number of seconds since the sound started playing.

dt\_stop:           the number of seconds after the sound has stopped.

#### <delay-sec>

Defines the delay after the volume block becomes active.

An example would be to have two sounds that relate to a single property and the delay-sec element can be used to allow one sound to start after the end of the first one simply by setting the delay-sec to the duration of the sample.

#### <type>

Defines the function that should be used upon the property before it is used for calculating the net result:

lin:               linear handling of the property value.  
                    this is the default.

ln:                convert the property value to a natural logarithmic value before scaling it. Anything below 1 will return zero.

log:               convert the property value to a true logarithmic value before scaling it. Anything below 1 will return zero.

inv:               inverse linear handling (1/x).

abs:               absolute handling of the value (always positive).

sqrt:              calculate the square root of the absolute value before scaling it.

#### <random>

Add a bit of randomness to the offset. Only used for pitch.

#### <min>

Minimum allowed value.

This is useful if sounds start to sound funny. Anything lower will be truncated to this value.

#### <max>

Maximum allowed value.

This is useful if sounds gets to loud. Anything higher will be

truncated to this value.

<position>

Specify the position of the sounds source relative to the aircraft center. The coordinate system used is a left hand coordinate system where +Y = left, -Y = right, -Z = down, +Z = up, -X = forward, +X = aft. Distances are in meters. The volume calculation due to distance and orientation of the sounds source ONLY work on mono samples!

<x>

X dimension offset

<y>

Y dimension offset

<z>

Z dimension offset

<orientation>

Specify the orientation of the sounds source.

The zero vector is default, indicating that a Source is not directional. Specifying a non-zero vector will make the Source directional in the X,Y,Z direction

<x>

X dimension

<y>

Y dimension

<z>

Z dimension

<inner-angle>

The inner edge of the audio cone in degrees (0.0 - 180.0). Any sound withing that angle will be played at the current gain.

<outer-angle>

The outer edge of the audio cone in degrees (0.0 - 180.0). Any sound beyond the outer cone will be played at "outer-gain" volume.

<outer-gain>

The gain at the outer edge of the cone.

<reference-dist>

Set a reference distance of sound in meters. This is the distance where the volume is at its maximum. Volume is clamped to this maximum for any distance below. Volume is attenuated for any distance above. Attenuation depends on reference and maximum distance. See OpenAL specification on "AL\_INVERSE\_DISTANCE\_CLAMPED" mode for details on exact computation.

<max-dist>

Set the maximum audible distance for the sound in meters. Sound is cut-off above this distance.

Creating a configuration file:



-----  
To make things easy, there is a default value for most entries to allow a sane configuration when a certain entry is omitted.

Default values are:

```
type:  lin
factor: 1.0
offset: 0.0 for volume, 1.0 for pitch
min:    0.0
max:    0.0 (don't check)
```

Calculations are made the following way (for both pitch and volume):

```
value = 0;
offs = 0;

for (n = 0; n < max; n++) {
    if (factor < 0)
    {
        value += offset[n] - abs(factor[n]) * function(property[n]);
    }
    else
    {
        value += factor[n] * function(property[n]);
        offs += offset[n];
    }
}

volume = offs + value;
```

where function can be one of: lin, ln, log, inv, abs or sqrt

## 43 Xmlsyntax

XML IN FIFTEEN MINUTES OR LESS

Written by David Megginson, david@megginson.com  
Last modified: \$Date\$

This document is in the Public Domain and comes with NO WARRANTY!

### 1. Introduction -----

FlightGear uses XML for much of its configuration. This document provides a minimal introduction to XML syntax, concentrating only on the parts necessary for writing and understanding FlightGear configuration files. For a full description, read the XML Recommendation at

<http://www.w3.org/TR/>

This document describes general XML syntax. Most of the XML configuration files in FlightGear use a special format called "Property Lists" -- a separate document will describe the specific features of the property-list format.

### 2. Elements and Attributes -----

An XML document is a tree structure with a single root, much like a file system or a recursive, nested list structure (for LISP fans). Every node in the tree is called an `_element_`: the start and end of every element is marked by a `_tag_`: the `_start tag_` appears at the beginning of the element, and the `_end tag_` appears at the end.

Here is an example of a start tag:

```
<foo>
```

Here is an example of an end tag:

```
</foo>
```

Here is an example of an element:

```
<foo>Hello, world!</foo>
```

The element in this example contains only data element, so it is a leaf node in the tree. Elements may also contain other elements, as in this example:

```
<bar>  
  <foo>Hello, world!</foo>  
  <foo>Goodbye, world!</foo>  
</bar>
```

This time, the 'bar' element is a branch that contains other, nested elements, while the 'foo' elements are leaf elements that contain only data. Here's the tree in ASCII art (make sure you're not using a proportional font):

```
bar +-- foo -- "Hello, world!"
```

```
|
+-- foo -- "Goodbye, world!"
```

There is always one single element at the top level: it is called the `_root element_`. Elements may never overlap, so something like this is always wrong (try to draw it as a tree diagram, and you'll understand why):

```
<a><b></a></b>
```

Every element may have variables, called `_attributes_`, attached to it. The attribute consists of a simple name=value pair in the start tag:

```
<foo type="greeting">Hello, world!</foo>
```

Attribute values must be quoted with `'` or `"` (unlike in HTML), and no two attributes may have the same name.

There are rules governing what can be used as an element or attribute name. The first character of a name must be an alphabetic character or `'_'`; subsequent characters may be `'_'`, `'-'`, `'.'`, an alphabetic character, or a numeric character. Note especially that names may not begin with a number.

### 3. Data

-----

Some characters in XML documents have special meanings, and must always be escaped when used literally:

```
<  &lt;
&  &amp;
```

Other characters have special meanings only in certain contexts, but it still doesn't hurt to escape them:

```
>  &gt;
'  &apos;
"  &quot;
```

Here is how you would escape `"x < 3 && y > 6"` in XML data:

```
x &lt; 3 &amp;&amp; y &gt; 6
```

Most control characters are forbidden in XML documents: only tab, newline, and carriage return are allowed (that means no `^L`, for example). Any other character can be included in an XML document as a character reference, by using its Unicode value; for example, the following represents the French word "café" with an accent on the final 'e':

```
caf&#233;
```

By default, 8-bit XML documents use UTF-8, **\*\*NOT\*\*** ISO 8859-1 (Latin 1), so it's safest always to use character references for characters above position 127 (i.e. for non-ASCII).

Whitespace always counts in XML documents, though some specific applications (like property lists) have rules for ignoring it in some contexts.

#### 4. Comments

-----

You can add a comment anywhere in an XML document except inside a tag or declaration using the following syntax:

```
<!-- comment -->
```

The comment text must not contain "--", so be careful about using dashes.

#### 5. XML Declaration

-----

Every XML document may begin with an XML declaration, starting with "<?xml" and ending with "?>". Here is an example:

```
<?xml version="1.0" encoding="UTF-8"?>
```

The XML declaration must always give the XML version, and it may also specify the encoding (and other information, not discussed here). UTF-8 is the default encoding for 8-bit documents; you could also try

```
<?xml version="1.0" encoding="ISO-8859-1"?>
```

to get ISO Latin 1, but some XML parsers might not support that (FlightGear's does, for what it's worth).

#### 6. Other Stuff

-----

There are other kinds of things allowed in XML documents. You don't need to use them for FlightGear, but in case anyone leaves one lying around, it would be useful to be able to recognize it.

XML documents may contain different kinds of declarations starting with "<!" and ending with ">":

```
<!DOCTYPE html SYSTEM "html.dtd">
```

```
<!ELEMENT foo (#PCDATA)>
```

```
<!ENTITY myname "John Smith">
```

and so on. They may also contain processing instructions, which look a bit like the XML declaration:

```
<?foo processing instruction?>
```

Finally, they may contain references to `_entities_`, like the ones used for escaping special characters, but with different names (we're trying to avoid these in FlightGear):

```
&chapter1;
```

```
&myname;
```

Enjoy.

## 44 Yasim

Coordinate system notes: All positions specified are in meters (which is weird, since all other units in the file are English). The X axis points forward, Y is left, and Z is up. Take your right hand, and hold it like a gun. Your first and second fingers are the X and Y axes, and your upwards-pointing thumb is the Z. This is slightly different from the coordinate system used by JSBSim. Sorry. The origin can be placed anywhere, so long as you are consistent. I use the nose of the aircraft.

### XML Elements

-----

airplane: The top-level element for the file. It contains only one attribute:

mass: The empty (no fuel) weight, in pounds.

approach: The approach parameters for the aircraft. The solver will generate an aircraft that matches these settings. The element can (and should) contain <control> elements indicating pilot input settings, such as flaps and throttle, for the approach.

speed: The approach airspeed, in knots TAS.

aoa: The approach angle of attack, in degrees

fuel: Fraction (0-1) of fuel in the tanks. Default is 0.2.

cruise: The cruise speed and altitude for the solver to match. As above, this should contain <control> elements indicating aircraft configuration. Especially, make sure the engines are generating enough thrust at cruise!

speed: The cruise speed, in knots TAS.

alt: The cruise altitude, in feet MSL.

fuel: Fraction (0-1) of fuel in the tanks. Default is 0.2.

cockpit: The location of the cockpit (pilot eyepoint).

x,y,z: eyepoint location (see coordinates note)

fuselage: This defines a tubelike structure. It will be given an even mass and aerodynamic force distribution by the solver. You can have as many as you like, in any orientation you please.

ax,ay,az: One end of the tube (typically the front)

bx,by,bz: The other ("back") end.

width: The width of the tube, in meters.

taper: The approximate radius at the "tips" of the fuselage expressed as a fraction (0-1) of the width value.

midpoint: The location of the widest part of the fuselage, expressed as a fraction of the distance between A and B.

idrag: Multiplier for the "induced drag" generated by this object. Default is one. With idrag=0 the fuselage generates only drag.

cx,cy,cz: Factors for the generated drag in the fuselages "local coordinate system" with x pointing from end to front, z perpendicular to x with y=0 in the aircraft coordinate system. E.g. for a fuselage of a height of 2 times the width you can define cy=2 and (due to the doubled front surface) cx=2.

wing: This defines the main wing of the aircraft. You can have only one (but see below about using vstab objects for extra lifting surfaces). The wing should have a <stall> subelement to indicate stall behavior, control surface subelements (flap0, flap1, spoiler, slat) to indicate what and where the control

surfaces are, and <control> subelements to map user input properties to the control surfaces.

x,y,z: The "base" of the wing, specified as the location of the mid-chord (not leading edge, trailing edge, or aerodynamic center) point at the root of the LEFT (!) wing.

length: The length from the base of the wing to the midchord point at the tip. Note that this is not the same thing as span.

chord: The chord of the wing at its base, along the X axis (not normal to the leading edge, as it is sometimes defined).

incidence: The incidence angle at the wing root, in degrees. Zero is level with the fuselage (as in an aerobatic plane), positive means that the leading edge is higher than the trailing edge (as in a trainer).

twist: The difference between the incidence angle at the wing root and the incidence angle at the wing tip. Typically, this is a negative number so that the wing tips have a lower angle of attack and stall after the wing root (washout).

taper: The taper fraction, expressed as the tip chord divided by the root chord. A taper of one is a hershey bar wing, and zero would be a wing ending at a point. Defaults to one.

sweep: The sweep angle of the wing, in degrees. Zero is no sweep, positive angles are swept back. Defaults to zero.

dihedral: The dihedral angle of the wing. Positive angles are upward dihedral. Defaults to zero.

idrag: Multiplier for the "induced drag" generated by this surface. In general, low aspect wings will generate less induced drag per-AoA than high aspect (glider) wings. This value isn't constrained well by the solution process, and may require tuning to get throttle settings correct in high AoA (approach) situations.

camber: The lift produced by the wing at zero angle of attack, expressed as a fraction of the maximum lift produced at the stall AoA.

hstab: These defines the horizontal stabilizer of the aircraft. Internally, it is just a wing object and therefore works the same in XML. You are allowed only one hstab object; the solver needs to know which wing's incidence to play with to get the aircraft trimmed correctly.

vstab: A "vertical" stabilizer. Like hstab, this is just another wing, with a few special properties. The surface is not "mirrored" as are wing and hstab objects. If you define a left wing only, you'll only get a left wing. The default dihedral, if unspecified, is 90 degrees instead of zero. But all parameters are equally settable, so there's no requirement that this object be "vertical" at all. You can use it for anything you like, such as extra wings for biplanes. Most importantly, these surfaces are not involved with the solver computation, so you can have none, or as many as you like.

mstab: A mirrored horizontal stabilizer. Exactly the same as wing, but not involved with the solver computation, so you can have none, or as many as you like.

stall: A subelement of a wing (or hstab/vstab/mstab) that specifies the stall behavior.

aoa: The stall angle (maximum lift) in degrees. Note that this is relative to the wing, not the fuselage (since the wing may have a non-zero incidence angle).

width: The "width" of the stall, in degrees. A high value indicates a gentle stall. Low values are viscious for a non-twisted wing, but are acceptable for a twisted one (since the whole wing will not stall at the same time).

peak: The height of the lift peak, relative to the post-stall secondary lift peak at 45 degrees. Defaults to 1.5. This one is deep voodoo, and probably doesn't need to change much. Bug me for an explanation if you're curious.

flap0, flap1, slat, spoiler:

These are subelements of wing/hstab/vstab objects, and specify the location and effectiveness of the control surfaces.

start: The position along the wing where the control surface begins. Zero is the root, one is the tip.

end: The position where the surface ends, as above.

lift: The lift multiplier for a flap or slat at full extension. One is a no-op, a typical aileron might be 1.2 or so, a giant jetliner flap 2.0, and a spoiler 0.0. For spoilers, the interpretation is a little different -- they spoil only "pre stall" lift. Lift due purely to "flat plate" effects isn't affected. For typical wings that stall at low AoA's essentially all lift is pre-stall and you don't have to care. Jet fighters tend not to have wing spoilers, for exactly this reason. This value is not applicable to slats, which affect stall AoA only.

drag: The drag multiplier, as above. Typically should be higher than the lift multiplier for flaps.

aoa: Applicable only to slats. This indicates the angle by which the stall AoA is translated by the slat extension.

thruster: A very simple "thrust only" engine object. Useful for things like thrust vectoring nozzles. All it does is map its THROTTLE input axis to its output thrust rating. Does not consume fuel, etc...

thrust: Maximum thrust in pounds

x,y,z: The point on the airframe where thrust will be applied.

vx,vy,vz: The direction of the thrust in airframe coordinates. The vector will be normalized automatically, so any non-zero vector will work fine.

jet: A turbojet/fan engine. It accepts a <control> subelement to map a property to its throttle setting, and an <actionpt> subelement to place the action point of the thrust at a different position than the mass of the engine.

x,y,z: The location of the engine, as a point mass. If no actionpt is specified, this will also be the point of application of thrust.

mass: The mass of the engine, in pounds.

thrust: The maximum sea-level thrust, in pounds.

afterburner: Maximum total thrust with afterburner/reheat,

in pounds [defaults to "no additional thrust"].

rotate: Vector angle of the thrust in degrees about the Y axis [0].

n1-idle: Idling rotor speed [55].

n1-max: Maximum rotor speed [102].

n2-idle: Idling compressor speed [73].

n2-max: Maximum compressor speed [103].

tsfc: Thrust-specific fuel consumption [0.8].  
This should be considerably lower for modern turbofans.

egt: Exhaust gas temperature at takeoff [1050].

epr: Engine pressure ratio at takeoff [3.0].

exhaust-speed: The maximum exhaust speed in knots [~1555].

spool-time: Time, in seconds, for the engine to respond to 90% of a commanded power setting.

propeller: A propeller. This element requires an engine subtag. Currently <piston-engine> and <turbine-engine> are supported.

x,y,z: The position of the mass (!) of the engine/propeller combination. If the point of force application is different (and it will be) it should be set with an <actionpt> subelement.

mass: The mass of the engine/propeller, in pounds.

moment: The moment, in kg-meters<sup>2</sup>. This has to be hand calculated and guessed at for now. A more automated system will be forthcoming. Use a negative moment value for counter-rotating ("European" -- CCW as seen from behind the prop) propellers. A good guess for this value is the radius of the prop (in meters) squared times the mass (kg) divided by three; that is the moment of a plain "stick" bolted to the prop shaft.

radius: The radius, in meters, of the propeller.

cruise-speed: The max efficiency cruise speed of the propeller. Generally not the same as the aircraft's cruise speed.

cruise-rpm: The RPM of the propeller at max-eff. cruise.

cruise-power: The power sunk by the prop at cruise, in horsepower.

cruise-alt: The reference cruise altitude in feet.

takeoff-power: The takeoff power required by the propeller...

takeoff-rpm: ...at the given takeoff RPM.

min-rpm: The minimum operational RPM for a constant speed propeller. This is the speed to which the prop governor will seek when the blue lever is at minimum. The coarse-stop attribute limits how far the governor can go into trying to reach this RPM.

max-rpm: The maximum operational RPM for a constant speed propeller. See above. The fine-stop attribute limits how far the governor can go in trying to reach this RPM.

fine-stop: The minimum pitch of the propeller (high RPM) as a ratio of ideal cruise pitch. This is set to 0.25 by default -- a higher value will result in a lower RPM at low power settings (e.g. idle, taxi, and approach).

coarse-stop: The maximum pitch of the propeller (low RPM) as a ratio of ideal cruise pitch. This is set to 4.0 by default -- a lower value may result in a



higher RPM at high power settings.

gear-ratio: The factor by which the engine RPM is multiplied to produce the propeller RPM. Optional (defaults to 1.0).

contra: When set (contra="1"), this indicates that the propeller is a contra-rotating pair. It will not contribute to the aircraft's net gyroscopic moment, nor will it produce asymmetric torque on the aircraft body. Asymmetric slipstream effects, when implemented, will also be zero when this is set.

piston-engine: A piston engine definition. This must be a subelement of an enclosing <propeller> tag.

eng-power: Maximum BHP of the engine at sea level.

eng-rpm: The engine RPM at which eng-power is developed

displacement: The engine displacement in cubic inches.

compression: The engine compression ratio.

turbo-mul: The turbo/super-charger pressure multiplier. Static pressure will be multiplied by this value to get the manifold pressure.

wastegate-mp: The maximum manifold pressure. Beyond this, the gate will release to keep the MP below this number. (inHG). This value can be changed at runtime using the WASTEGATE control axis, which is a multiplier in the range [0:1].

turbo-lag: Time lag, in seconds, for 90% of a power change to be reflected in the turbocharger boost pressure.

turbine-engine: A turbine engine definition. This must be a subelement of an enclosing <propeller> tag.

eng-power: Maximum BHP of the engine at a suitable cruise altitude.

eng-rpm: The engine RPM at which eng-power is developed. Note that this is "shaft" RPM as seen by the propeller. Don't use a gear-ratio on the enclosing propeller, or else you'll get confused. :)

alt: The altitude at which eng-power is developed. This should be high enough to be lower (!) than the flat-rating power.

flat-rating: The maximum allowed power developed by the engine. Most turboprops are flat rated below a certain altitude and temperature range to prevent engine damage.

min-n2: N2 (percent) turbine speed at zero throttle.

max-n2: N2 (percent) turbine speed at max throttle.

bsfc: Specific fuel consumption, in lbs/hr per horsepower.

actionpt: Defines an "action point" for an enclosing jet or propeller element. This is the location where the force from the thruster will be applied.

x,y,z: The location of force application.

gear: Defines a landing gear. Accepts <control> subelements to map properties to steering and braking. Can also be used to simulate floats. Although the coefficients are still called ..fric, it

is calculated in fluids as a drag (proportional to the square of the speed). In fluids gears are not considered to detect crashes (as on ground).

x,y,z: The location of the fully-extended gear tip.

compression: The distance in meters along the "up" axis that the gear will compress.

initial-load: The initial load of the spring in multiples of compression. Defaults to 0. (With this parameter a lower spring-constants will be used for the gear-> can reduce numerical problems (jitter))  
 Note: the spring-constant is varied from 0% compression to 20% compression to get continuous behavior around 0 compression. (could be physically explained by wheel deformation)

upx/upy/upz: The direction of compression, defaults to vertical (0,0,1) if unspecified. These are used only for a direction -- the vector need not be normalized, as the length is specified by "compression".

sfri: Static (non-skidding) coefficient of friction. Defaults to 0.8.

dfri: Dynamic friction. Defaults to 0.7.

spring: A dimensionless multiplier for the automatically generated spring constant. Increase to make the gear stiffer, decrease to make it squishier.

damp: A dimensionless multiplier for the automatically generated damping coefficient. Decrease to make the gear "bouncier", increase to make it "slower". Beware of increasing this too far: very high damping forces can make the numerics unstable. If you can't make the gear stop bouncing with this number, try increasing the compression length instead.

on-water: if this is set to "0" the gear will be ignored if on water. Defaults to "0"

on-solid: if this set to "0" the gear will be ignored if not on water. Defaults to "1"

speed-planing:

spring-factor-not-planing: At zero speed the spring factor is multiplied by spring-factor-not-planing. Above speed-planing this factor is equal to 1. The idea is, to use this for floats simulating the transition from swimming to planing. speed-planing defaults to 0, spring-factor-not-planing defaults to 1.

reduce-friction-by-extension: at full extension the friction is reduced by this relative value. 0.7 means 30% friction at full extension. If you specify a value greater than one, the friction will be zero before reaching full extension. Defaults to "0"

ignored-by-solver: with the on-water/on-solid tags you can have more than one set of gears in one aircraft, If the solver (who automatically generates the spring constants) would take all gears into account, the result would be wrong. E. G. set this tag to "1" for all gears, which are not active on runways. Defaults to "0". You can not exclude all gears in the solving process.

launchbar: Defines a catapult launchbar or strop. The default acceleration provided by the catapult is 25m/s<sup>2</sup>. This can be modified by the use of the control axis LACCEL.

x,y,z: The location of the mount point of the launch bar or

strop on the aircraft.  
 length: The length of the launch bar from mount point to tip  
 down-angle: The max angle below the horizontal the launchbar can achieve.  
 up-angle: The max angle above the horizontal the launchbar can achieve.  
 holdback-{x,y,z}: The location of the holdback mount point on the aircraft.  
 holdback-length: The length of the holdback from mount point to tip. Note: holdback up-angle and down-angle are the same as those defined for the launchbar and are not specified in the configuration.

tank: A fuel tank. Tanks in the aircraft are identified numerically (starting from zero), in the order they are defined in the file. If the left tank is first, "tank[0]" will be the left tank.  
 x,y,z: The location of the tank.  
 capacity: The maximum contents of the tank, in pounds. Not gallons -- YASim supports fuels of varying densities.  
 jet: A boolean. If present, this causes the fuel density to be treated as Jet-A. Otherwise, gasoline density is used. A more elaborate density setting (in pounds per gallon, for example) would be easy to implement. Bug me.

ballast: This is a mechanism for modifying the mass distribution of the aircraft. A ballast setting specifies that a particular amount of the empty weight of the aircraft must be placed at a given location. The remaining non-ballast weight will be distributed "intelligently" across the fuselage and wing objects. Note again: this does NOT change the empty weight of the aircraft.  
 x,y,z: The location of the ballast.  
 mass: How much mass, in pounds, to put there. Note that this value can be negative. I find that I often need to "lighten" the tail of the aircraft.

weight: This is an added weight, something not part of the empty weight of the aircraft, like passengers, cargo, or external stores. The actual value of the mass is not specified here, instead, a mapping to a property is used. This allows external code, such as the panel, to control the weight (loading a given cargo configuration from preference files, dropping bombs at runtime, etc...)  
 x,y,z: The location of the weight.  
 mass-prop: The name of the fgfs property containing the mass, in pounds, of this weight.  
 size: The aerodynamic "size", in meters, of the object. This is important for external stores, which will cause drag. For reasonably aerodynamic stuff like bombs, the size should be roughly the width of the object. For other stuff, you're on your own. The default is zero, which results in no aerodynamic force (internal cargo).

solve-weight: Subtag of approach and cruise parameters. Used to specify a non-zero setting for a <weight> tag during solution. The default is to assume all weights are zero at the given

performance numbers.

idx: Index of the weight in the file (starting with zero).

weight: Weight setting in pounds.

#### control-input:

This element manages a mapping from fgfs properties (user input) to settable values on the aircraft's objects. Note that the value to be set MUST (!) be valid on the given object type. This is not checked for by the parser, and will cause a runtime crash if you try it. Wing's don't have throttle controls, etc... Note that multiple axes may be set on the same value. They are summed before setting.

axis: The name of the double-valued fgfs property "axis" to use as input, such as "/controls/flight/aileron".

control: Which control axis to set on the objects. It can have the following values:

THROTTLE - The throttle on a jet or propeller.

MIXTURE - The mixture on a propeller.

REHEAT - The afterburner on a jet

PROP - The propeller advance

BRAKE - The brake on a gear.

STEER - The steering angle on a gear.

INCIDENCE - The incidence angle of a wing.

FLAP0 - The flap0 deflection of a wing.

FLAP1 - The flap1 deflection of a wing.

FLAP[0/1]EFFECTIVENESS - a multiplier for flap lift, but not drag (useful for blown flaps)

SLAT - The slat extension of a wing.

SPOILER - The spoiler extension for a wing.

CYCLICAIL - The "aileron" cyclic input of a rotor

CYCLICELE - The "elevator" cyclic input of a rotor

COLLECTIVE - The collective input of a rotor

ROTORENGINEON - If not equal zero the rotor is rotating

WINCHRELSPEED - The relative winch speed

LACCEL - The acceleration provided by the catapult.

{... and many more, see FGFDM.cpp ...}

invert: Negate the value of the property before setting on the object.

split: Applicable to wing control surfaces. Sets the normal value on the left wing, and a negated value on the right wing.

square: Squares the value before setting. Useful for controls like steering that need a wide range, yet lots of sensitivity in the center. Obviously only applicable to values that have a range of [-1:1] or [0:1].

src0/src1/dst0/dst1:

If present, these defined a linear mapping from the source to the output value. Input values in the range src0-src1 are mapped linearly to dst0-dst1, with clamping for input values that lie outside the range.

#### control-output:

This can be used to pass the value of a YASim control axis (after all mapping and summing is applied) back to the property tree.

control: Name of the control axis. See above.

prop: Property node to receive the value.

side: Optional, for split controls. Either "right" or "left"

min/max: Clamping applied to output value.

control-speed:

Some controls (most notably flaps and hydraulics) have maximum slew rates and cannot respond instantly to pilot input. This can be implemented with a control-speed tag, which defines a "transition time" required to slew through the full input range. Note that this tag is semi-deprecated, complicated control input filtering can be done much more robustly from a Nasal script.

control: Name of the control axis. See above.

transition-time: Time in seconds to slew through input range.

control-setting:

This tag is used to define a particular setting for a control axis inside the <cruise> or <approach> tags, where obviously property input is not available. It can be used, for example, to inform the solver that the approach performance values assume full flaps, etc...

axis: Name of the control input (i.e. a property name)

value: Value of the control axis.

hitch: A hitch, can be used for winch-start (in gliders) or aerotow (in gliders and motor aircrafts) or for external cargo with helicopter. You can do aerotow over the net via multiplayer (see j3 and bocian as an example).

name: the name of the hitch. must be aerotow if you want to do aerotow via multiplayer. You will find many properties at /sim/hitches/name. Most of them are directly tied to the internal variables, you can modify them as you like. You can add a listener to the property "broken", e. g. for playing a sound.

x,y,z: The position of the hitch

force-is-calculated-by-other: if you want to simulate aerotowing over the internet, set this value to "1" in the motor aircraft. Don't specify or set this to zero in gliders. In a LAN the time lag might be small enough to set it on both aircrafts to "0". It's intended, that this is done automatically in the future.

tow: The tow used for aerotow or winch. This must be a subelement of an enclosing <hitch> tag.

length: upstretched length in m

weight-per-meter: in kg/m

elastic-constant: lower values give higher elasticity

break-force: in N

mp-auto-connect-period: the every x seconds a towed multiplayer aircraft is searched. If found, this tow is connected automatically, parameters are copied from the other aircraft. Should be set only in the motor aircraft, not in the glider

winch: The tow used for aerotow or winch. This must be a subelement of an enclosing <hitch> tag.

max-tow-length:

min-tow-length:

initial-tow-length: all are in m. The initial tow length also defines the length/search radius used for the mp-autoconnect feature

max-winch-speed: in m/s

power: in kW  
max-force: in N

rotor: A rotor. Used for simulating helicopters. You can have one, two or even more.  
There is a drawing of a rotor in the Doc-directory (README.yasim.rotor.png) Please find the measures from this drawing for several parameters in square brackets [].  
If you specify a rotor, you do not need to specify a wing or hstab, the settings for approach and cruise will be ignored then. You have to specify the solver results manually. See below.  
The rotor generates downwash acting on all stabs, surfaces and fuselages. For all fuselages in the rotor downwash you should specify idrag="0" to get realistic results.

name: The name of the rotor.  
(some data is stored at /rotors/name/)  
The rpm, cone angle, yaw angle and roll angle are stored for the complete rotor. For every blade the position angle, the flap angle and the incidence angle are stored. All angles are in degree, positive values always mean "up". This is not completely tested, but seem to work at least for rotors rotating counterclockwise.  
A value stall gives the fraction of the rotor in stall (weighted by the fraction the have on lift and drag without stall). Use this for modifying the rotor-sound.

x,y,z: The position of the rotor center

nx,ny,nz: The normal of the rotor (pointing upwards, will be normalized by the computer)

fx,fy,fz: A Vector pointing forward, if not perpendicular to the normal it will be corrected by the computer

diameter: The diameter in meter [D]

numblades: The number of blades

weightperblade: The weight per blade in pounds

relbladecenter: The relative center of gravity of the blade. Maybe not 100% correct interpreted; use 0.5 for the start and change in small steps [b/R]

chord: The chord of the blade its base, along the X axis (not normal to the leading edge, as it is sometimes defined). [c]

twist: The difference between the incidence angle at the blade root and the incidence angle at the wing tip. Typically, this is a negative number so that the rotor tips have a lower angle of attack.

taper: The taper fraction, expressed as the tip chord divided by the root chord. A taper of one is a bar blade, and zero would be a blade ending at a point. Defaults to one. [d/c]

rel-len-where-incidence-is-measured: If the blade is twisted, you need a point where to measure the incidence angle. Zero means at the base, 1 means at the tip. Typically it should be something near 0.7

rel-len-blade-start: Typically the blade is not mounted in the center of the rotor [a/R]

rpm: rounds per minute.

phi0: initial position of this rotor

ccw: determines if the rotor rotates clockwise ("0") or counterclockwise ("1"), (if you look on the top of the normal, so the bo105 has counterclockwise rotor).  
"true" and "false" are not any longer supported to increase my lifespan. ;-)

maxcollective: The maximum of the collective incidence in degree

mincollective: The minimum of the collective incidence in degree  
 maxcycliccele: The maximum of the cyclic incidence in degree for  
     the elevator like function  
 mincycliccele: The minimum of the cyclic incidence in degree for  
     the elevator like function  
 maxcyclicail: The maximum of the cyclic incidence in degree for  
     the aileron like function  
 mincyclicail: The minimum of the cyclic incidence in degree for  
     the aileron like function  
 airfoil-incidence-no-lift: non symmetric airfoils produces lift  
     with no incidence. This is is the incidence, where the  
     airfoil is producing no lift. Zero for symmetrical airfoils  
     (default)  
 incidence-stall-zero-speed:  
 incidence-stall-half-sonic-speed: the stall incidence is a function  
     of the speed. I found some measured data, where this is  
     linear over a wide range of speed. Of course the linear  
     region ends at higher speeds than zero, but just  
     extrapolate the linear behavior to zero.  
 lift-factor-stall: In stall airfoils produce less lift. Without  
     stall the c-lift of the profile is assumed to be  
      $\sin(\text{incidence} - \text{"airfoil-incidence-no-lift"}) * \text{liftcoef}$ ;  
     And in stall:  
      $\sin(2 * (\text{incidence} - \text{"airfoil-incidence-no-lift"})) * \text{liftcoef} * \dots$   
      $\dots \text{"lift-factor-stall"}$ ;  
     Therefore this factor is not the quotient between lift  
     with and without stall. Use 0.28 if you have no idea.  
 drag-factor-stall: The drag of an airfoil in stall is larger than  
     without stall.  
     Without stall c-drag is assumed to be  
      $\text{abs}(\sin(\text{incidence} - \text{"airfoil-incidence-no-lift"})) \dots$   
      $\dots * \text{dragcoef1} + \text{dragcoef0}$ ;  
     With stall this is multiplied by drag-factor  
 stall-change-over: For incidence < "incidence-stall" there is no stall.  
     For incidence > ("incidence-stall" + "stall-change-over") there  
     is stall. In the range between this incidences it is  
     interpolated linear.  
  
 pitch-a:  
 pitch-b: collective incidence angles, If you start flightgear  
     with --log-level=info, flightgear reports lift and needed  
     power for theses incidence angles  
 forceatpitch-a:  
 poweratpitch-b:  
 poweratpitch-0: old tokens, not supported any longer, the result are  
     not exactly the expected lift and power values. Will be  
     removed in one of the next updates. Use "real"  
     coefficients instead (see below) and adjust the lift with  
     rotor-correction-factor.  
  
 The airfoil of the rotor is described as follows:  
 The way is to define the lift and drag coefficients directly.  
 Without stall the c-lift of the profile is assumed to be  
      $\sin(\text{incidence} - \text{"airfoil-incidence-no-lift"}) * \text{liftcoef}$ ;  
 And in stall:  
      $\sin(2 * (\text{incidence} - \text{"airfoil-incidence-no-lift"})) * \text{liftcoef} * \dots$   
      $\dots \text{"lift-factor-stall"}$ ;  
 Without stall c-drag is assumed to be  
      $\text{abs}(\sin(\text{incidence} - \text{"airfoil-incidence-no-lift"})) \dots$   
      $\dots * \text{dragcoef1} + \text{dragcoef0}$ ;  
 See above, how the coefficients are defined with stall.  
 The parameters:  
 airfoil-lift-coefficient: liftcoef

airfoil-drag-coefficient0: dragcoef0  
airfoil-drag-coefficient1: dragcoef1  
To find the right values: see README.yasim.rotor.ods (Open Office file) or README.yasim.rotor.xls (Excel file). With these files you can generate graphs of the airfoil coefficients and adjust the parameters to match real airfoils. For many airfoils you find data published in the internet. Parameters for the airfoils NACA 23012 (main rotor of bo105) and NACA 0012 (tail rotor of bo105?) are included.

rotor-correction-factor:  
If you calculate the lift of a heli rotor or even of a propeller, you get a value larger than the real measured one. (Due to vortex effects.) This is considered in the simulation, but with a old theory by Prantl, which is known to give still too large. This is corrected by this token, default: 1

flapmin: Minimum flapping angle. (Should normally never reached)  
flapmax: Maximum flapping angle. (Should normally never reached)  
flap0: Flapping angle at no rotation, i.e. -5  
dynamic: this changes the reactions speed of the rotor to an input. normally 1 (Maybe there are rotors with a little faster reaction, than use a value a little greater than one. A value greater than one will result in a more inert, system. Maybe it's useful for simulating the rotor of the Bell UH1

rellenflaphinge: The relative length from the center of the rotor to the flapping hinge. Can be taken from pictures of the helicopter (i.e. 0 for Bell206, about 0.05 for most rotors) For rotors without flapping hinge (where the blade are twisted instead, i.e. Bo 105, Lynx) use a mean value, maybe 0.2. This value has a extreme result in the behavior of the rotor  $[F/r]$

sharedflaphinge: determines, if the rotor has one central flapping hinge ("1") for the blades (like the Bell206 or the tail rotor of the Bo 105), default is "0".

delta3: Some rotors have a delta3 effect, which results in a decreasing of the incidence when the rotor is flapping. A value of 0 (as most helicopters have) means no change in incidence, a value of 1 result in a decreases of one degree per one degree flapping. So delta3 is the proportional factor between flapping and decrease of incidence. I.e. the tail rotor of a Bo105 has a delta3 of 1. In some publications delta3 is described by an angle. The value in YASim is the atan of this angle

delta: A factor for the damping constant for the flapping. 1 means a analytical result, which is only a approximation. Has a very strong result in the reaction of the rotor system on control inputs. If you know the flapping angle for a given cyclic input you can adjust this by changing this value. Or if you now the maximum roll rate or ...

translift-maxfactor: Helicopters have "translational lift", which is due to turbulence. In forward flying the rotor gets less turbulence air and produces more lift. The factor is the quotient between lift at high airspeeds to the lift at hover (with same pitch).

translift-ve: the speed, where the translational lift reaches 1/e of the maximum value. In m/s.

ground-effect-constant: Near to the ground the rotor produces more torque than in higher altitudes. The ground effect is



calculated as  
 factor = 1+diameter/altitude\*"ground-effect-constant"  
 number-of-parts:  
 number-of-segments: The rotor is simulated in "number-of-parts"  
 different directions.  
 In every direction the rotor is simulated at  
 number-of-segments points. If the value is too small, the  
 rotor will react unrealistically. If it is too high, CPU-power  
 will be wasted. I now use a value of 8 for  
 "number-of-parts" and 8 for number-of-segments for the main  
 rotor and 4 for "number-of-parts" and 5 for  
 "number-of-segments" for the tail rotor.  
 "number-of-parts" must be a multiple of 4 (if not, it  
 is corrected)  
 cyclic-factor: The response of a rotor to cyclic input is hard to  
 calculate (it's a damped oscillator in resonance, some  
 parameters have very large impact to the cyclic response)  
 With this parameter (default 1) you can adjust the  
 simulator to the real helo.  
 downwashfactor: A factor for the downwash of the rotor, default 1.  
 balance: The balance of the rotor. 1.0: the rotor is 100% balanced,  
 0.0: half of the blades are missing. Use a value near one  
 (0.98 ... 0.999) to add some vibration.  
 tiltcenterx:  
 tiltcentery:  
 tiltcenterz: The center for the tilting of the complete rotorhead/  
 mast. Can be used for simulating of the Osprey or small  
 autogyros.  
 mintilt yaw:  
 mintilt pitch:  
 mintilt roll:  
 maxtilt yaw:  
 maxtilt pitch:  
 maxtilt roll: The limits (in degree) for tilting the rotor head

All rotor can have <control> subelements for the cyclic  
 (CYCLICELE, CYCLICAIL) and collective (COLLECTIVE) input.  
 and can have <control> subelements for the tilting the whole rotor  
 head around the y-axis (TILTPITCH), the x-axis (TILTROLL) and the  
 z-axis (TILTYAW). ROTORBALANCE is a factor for the balance.

rotorgear: If you are using one or more rotors you have to define a  
 rotorgear. It connects all the rotors and adds a simple engine.  
 In future it will be possible, to add a YASim-engine.  
 max-power-engine: the maximum power of the engine, in kW.  
 engine-prop-factor: the engine is working as a pd-regulator. This  
 is the width of the regulation-band, or, in other words,  
 the inverse of the proportional-factor of the regulator.  
 If you set it to 0.02, then up to 98% of the rotor-rpm  
 the engine will produce maximum torque. At 100% of  
 the engine will produce no torque. It is planned to use  
 YASim-engines instead of this simple engine.  
 engine-accel-limit: The d-factor of the engine is defined as the  
 maximum acceleration rate of the engine in %/s,  
 default is 5%/s.  
 max-power-rotor-brake: the maximum power of the rotor brake, in kW  
 at normal rpm (most? real rotor brakes would be overheated  
 if used at normal rpm, but this is not simulated now)  
 rotorgear-friction: the power loss due to friction in kW at normal  
 RPM  
 yasimdragfactor:  
 yasimliftfactor: the solver is not working with rotor-aircraft.  
 Therefore you have to specify the results yourself.

10 for drag and 140 for lift seem to be good starting values. Although the solve is not invoked for aircraft with at least one rotor, you need to specify the cruise and the approach settings. The approach speed is needed to calculate the gear springs. Use a speed of approx. 50knots. They do not need to match any real value.

The rotorgear needs a <control> subelement for the engine (ROTORGEARENGINEON) and can have further <control> subelements:

ROTORBRAKE: rotor brake

ROTORRELTARGET: the target rpm of the engine relative to the "normal" value for the governor. Default is 1.

ROTORENGINEMAXRELTORQUE: the maximum torque of the engine relative to the torque defined by the engine-power. Default is 1. By setting the rel-target to a large number you get control over the engine by this control.

Alternatively you can use these two values for individual start-up sequences (see the s58)