

Avaneya Crew Handbook

A comprehensive guide for all of our bold contributors.

The Avaneya Crew

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1 Preface

The purpose of this handbook is to define the Avaneya project as clearly as possible so that everyone who is involved in its creation understands it. The book is probably not as useful to normal users as it is to contributors. In fact, it may even spoil elements of the game for the latter. On the other hand, normal users are just as likely to enrich the game through their feedback - feedback which is best supported through an understanding of the project's aims.

It is also useful to have the project as well defined as possible in a single location. This is handy for those of us that may live in remote areas and have infrequent internet access from their machine, as is currently the case with some, but still want to contribute in whatever way they can.

2 The Game

2.1 Why?

Too often, people have come out of experiencing a great dystopian science fiction novel or film, only to say to themselves, Thank goodness we don't live in *that* world! That needs to change.

Dystopian science fiction can arguably be among the most honest kind of story telling when examined in the context of history. But unless people can see the connection between the world they perceived in fiction and the one they inhabit, vague analogies and cryptic metaphors tend to have minimal utility as pedagogical aids.

But *good* science fiction is only *partly* fiction because it is often the *science* portion that is what attracts people to it in the first place. Science, by its nature, is a thinking and knowledge oriented enterprise - not unlike the people that tend to gravitate towards the aforementioned genre. This can set the bar high for what they expect and requires designers to pay a great deal of attention to detail. A certain degree of artistic license is to be expected, but users still expect it to be as consistent with what we already know to be true or what is at least reasonably plausible. It may be because of the thinking and learning aspect that we are seeing less and less science fiction entertainment as time goes on. That needs to change.

Another important reason is that there is very little, if any, free commercial entertainment for the GNU operating system. When people use GNU, they are treated as second class citizens in terms of the availability of high quality games. Not only are there very few higher production titles that are available for GNU, they are usually proprietary, and even then, generally bad ports using deprecated APIs, poorly packaged,¹ and integrate horribly into the user's desktop - ignoring the usual human factors community driven conventions.

But in terms of their subject matter itself, they tend to appeal more to the senses of the mainstream proprietary user, and thus do not reflect the spirit of a social conscience commonplace in the *software libre* community. That also needs to change.

2.2 Classification

People have struggled in the past to classify Avaneya. It is what it is, but the closest traditional categories that form a subset of it are the traditional city builder and management simulations and the real time strategy.

2.3 Who Is It For?

The game so far has attracted a fairly large base of followers. From what can be observed at this time, the game appears to appeal to those with an interest in:

- *software libre*
- *a social conscience*
- *science fiction*
- *the interconnectedness of everything*

¹ That is, if they even bother to use the platform's native distribution's package manager at all.

The game may take place in the future, but it deals with current problems. The best way to get an idea of the intended audience is to quickly see [\[Relevant Readings\]](#), page [\[undefined\]](#) and to ask yourself the type of audience that those resources would probably appeal to.

2.4 Who Is It Not For?

Avaneya is a *sui generis*. It is not like other games, and thus it is not for all people. Those who have a brief attention span or believe that things originate in cans, as in, little understanding and appreciation for process, will simply not enjoy this game. There are already many such games that appeal to that type of audience, so that need not be our aim here.

This game will challenge you to think, and possibly even offend you. Some have even accused Avaneya of being a vehicle for political views. The project is guilty as charged—like the newspapers, film, television, games, and other mainstream media that saturate us.

The only difference is that, unlike those mediums, the very presence of a normative bias in Avaneya is not subject to dispute and is self evident. Other mediums often pretend to not have one. In any case, you would be very hard pressed to try to find any classical work of science fiction, or really any kind of fiction for that matter, that did not. Moreover, that in itself is not necessarily a bad thing.

3 Relevant Learning Resources

You should be able to find all of these resources available either in digital format online, or in physical format at most major book stores. Most of them are not difficult to find.

3.1 For Everyone

These resources are useful for every kind of contributor, from researchers and writers to modellers and engineers.

You might consider reading some of these resources in order to enrich your understanding of the game, whose fabric is drawn from *at least* all of them. The more background knowledge we have, the greater the quality of the game. The same goes for really any kind of complex simulation, and not just Avaneya.

- *Blue Mars: Mars Trilogy Bk. 3*
Kim Stanley Robinson, Voyager, ISBN 9780586213919, 1997.
- *Death by Government*
R. J. Rummel, Transaction Publishers, ISBN 9781560009276, 1997.
- *Debunking 9/11 Debunking*
David Ray Griffin, Olive Branch Pr, ISBN 9781566566865, 2007.
- *Free Software, Free Society: Selected Essays of Richard M. Stallman*
Richard M. Stallman, Free Software Foundation, ISBN 9781882114986, 2002.
- *Green Mars: Mars Trilogy Bk. 2*
Kim Stanley Robinson, Voyager, ISBN 9780586213902, 1994.
- *How to Live on Mars: A Trusty Guidebook to Surviving and Thriving on the Red Planet*
Robert Zubrin, Three Rivers Press, ISBN 9780307407184, 2008.
- *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*
Naomi Oreskes et al., Bloomsbury Press, ISBN 9781596916104, 2010.
- *Minutes of Proceedings and Evidence Respecting the Bank of Canada*
Standing Committee on Banking and Commerce, 1939, pp. 461-500.
- *Open Letter to Minister of Public Safety Regarding 9/11*
Kip Warner, 2011.
- *Red Mars: Mars Trilogy Bk. 1*
Kim Stanley Robinson, Collins, ISBN 9780586213896, 1993.

- *Statistics of Democide: Genocide and Mass Murder since 1900 (Macht Und Gesellschaft, Bd. 2)*
R. J. Rummel, Lit Verlag, ISBN 9783825840105, 1999.
- *Terraforming: The Creating of Habitable Worlds (Astronomers' Universe)*
Martin Beech, Springer, ISBN 9780387097954, 2009.
- *The Case Against Fluoride: How Hazardous Waste Ended Up in Our Drinking Water and the Bad Science and Powerful Politics That Keep It There*
Paul Connett et al., Chelsea Green Publishing, ISBN 9781603582872, 2010.
- *The Case for Mars: The Plan to Settle the Red Planet and Why We Must*
Robert Zubrin et al., Free Press, 1997.
- *The China Study: The Most Comprehensive Study of Nutrition Ever Conducted and the Startling Implications for Diet, Weight Loss and Long-term Health*
T. Colin Campbell, Benbella Books, 2006.
- *The Creature from Jekyll Island: A Second Look at the Federal Reserve*
G. Edward Griffin, American Media, ISBN 9780912986395, 2010.

3.2 For Artists

These resources are useful for different kinds of artists, such as 2D artists, audio engineers, cinematic artists, modellers, musicians, and so on.

- *3D Computer Graphics, Second Edition*¹
Andrew Glassner, Green Editorial, ISBN 9781558213050, 1994.
- *Beginning GIMP: From Novice to Professional*
Akkana Peck, Apress, ISBN 9781430210702, 2009.
- *Blender 2.5 Materials and Textures Cookbook*
Colin Litster, Packt Publishing, ISBN 9781849512886, 2011.
- *Blender 3D 2.49 Incredible Machines*
Allan Brito, Packt Publishing, ISBN 9781847197467, 2009.
- *Blender 3D Architecture, Buildings, and Scenery: Create photorealistic 3D architectural visualizations of buildings, interiors, and environmental scenery*
Allan Brito, Packt Publishing, ISBN 9781847193674, 2008.

¹ This book is listed as a resource for artists because it is a wonderful and concise introduction to the theory of computer graphics, but for non-programmers and non-mathematicians. It is a classic, though long out of print. Nevertheless, you can probably find used copies for sale.

- *Blender Studio Projects: Digital Movie-Making*
Tony Mullen & Claudio Andaur, Sybex, ISBN 9780470543139, 2010.
- *Introducing Character Animation with Blender*
Tony Mullen, Sybex, ISBN 9780470102602, 2007.
- *The Essential Blender: Guide to 3D Creation with the Open Source Suite Blender*
Roland Hess, No Starch Press, ISBN 9781593271664, 2007.

3.3 For Engineers

These resources are useful mostly for engineers and other very technical work.

- *Autotools: A Practioner's Guide to GNU Autoconf, Automake, and Libtool*
John Calcote, No Starch Press, ISBN 9781593272067, 2010.
- *Beginning Game Audio Programming*
Mason McCuskey et al., Premier-Trade, ISBN 9781592000296, 2003.
- *Beginning iPhone Games Development*
PJ Cabrera et al., Apress, ISBN 9781430225997, 2010.
- *Design Patterns: Elements of Reusable Object-Oriented Software (Addison-Wesley Professional Computing Series)*
Gamma et al., Addison-Wesley Professional, Hardcover, ISBN 9780201633610, 1994.
- *Game Engine Architecture*
Jason Gregory, A K Peters/CRC Press, ISBN 9781568814131, 2009.
- *Lua 5.1 Reference Manual*
Roberto Ierusalimsky et al., Lua.org, ISBN 9788590379836, 2006.
- *Lua Programming Gems*
Lua.org, ISBN 9788590379843, 2008.
- *OpenGL Library (5th Edition)*
Dave Shreiner et al., Addison-Wesley Professional, ISBN 9780321637642, 2009.
- *Pro OGRE 3D Programming*
Gregory Junker, Apress, ISBN 9781590597101, 2006.
- *Programming in Lua, Second Edition*
Roberto Ierusalimsky, Lua.org, ISBN 9788590379829, 2006.

- *Systems and Models. Complexity, Dynamics, Evolution, Sustainability*
Hartmut Bossel, BoD, ISBN 9783833481215, 2007.
- *System Zoo 1 Simulation Models - Elementary Systems, Physics, Engineering*
Hartmut Bossel, BoD, ISBN 9783833484223, 2007.
- *System Zoo 2 Simulation Models. Climate, Ecosystems, Resources*
Hartmut Bossel, BoD, ISBN 9783833484230, 2007.
- *System Zoo 3 Simulation Models. Economy, Society, Development*
Hartmut Bossel, BoD, ISBN 9783833484247, 2007.

4 The Story

4.1 Background

4.2 Storyboard

4.2.1 Opening Cinematic

4.3 Fictional Timeline

5 The Game World

This chapter deals with some of the different aspects of the world the game takes place in, as one in that world itself might know it as.

5.1 Avaneya

5.2 Buildings

5.3 Characters

5.4 Economics

5.5 Environmental

5.6 Food

5.7 Ground Vehicles and Machinery

5.8 Indoors

5.9 Kit

5.10 Locations

5.11 Politics and Legal

5.12 Population

5.13 Resources

5.14 Time

5.15 Weapons

6 Gameplay

7 Selected Technology

It is generally a bad engineering practise to re-invent the wheel by creating something in a vacuum when there are already many usable components. Avaneya's dependent technology is examined here, grouped by category. It is sometimes explained in their maintainer's own words.

We always try to stick to using free software whenever possible. The only time we might use a non-free tool is to use it as a model in designing a suitable replacement. Another time would be where writing a replacement would be far too difficult and we have no choice.

7.1 Audio

- We use *libmikmod* for playback of tracker music modules. Some people were requesting tracker support, and since it should not take very much effort to integrate into the engine's *AudioManager* subsystem, it seems reasonable. The library also needs to be built thread safe.
- *OpenAL* is used for 3D spatial audio rendering. Actual decoding of audio data is done through other APIs.
- The *SDL* library is used to provide audio decoding through its *SDL_audio* API. It decodes popular formats like Ogg Vorbis.

7.2 Developer Tools

- The *CppUnit* library is a unit testing framework module for the C++ programming language, used only when the engine is built in debug mode.
- The *GNU Autotools* are used to reconcile and harmonize the idiosyncrasies of different platforms. It makes portability far more straightforward than without it.
- The *GNU Compiler Collection* is used for the engine's dependency calculation, compilation, and linking, among other things. Ports of virtually all of its compilers are available everywhere.
- *GNU gettext* is used for localization and translation to different human languages by making it possible to substitute strings that are marked for translation in our C++ code with a string from another language.
- The *libebml* library is the backbone of the Matroska multimedia container format. EBML stands for *Extensible Binary Meta Language*. It is often thought of as a binary analogue to the XML format, though not a complete analogue because, unlike XML, the schema must be known in advance. Therefore, it is ideally suited to be read and written by machines and not humans. See [Section 8.1 \[AresPackages\]](#), [page 15](#) for details on how we are using it in this project.

- The *streflop* library (*STandalone REproducible FLOating-Point*) allows you to control how floating point computations are done in C++. The goal is to make programs give reliable and reproducible results. This is important because differences in machine generated code, numeric handling libraries, dedicated hardware floating point processors, optimizations, and so on, can yield results that are inconsistent across different environments.
- The *xmlstarlet* tool is used to validate XML against a schema. It is useful to check AresPackage manifests and the engine event definition for syntactical errors.

7.3 Graphics

- All modelling is generally done with *Blender*, but modellers are free to use whatever free modelling application they like, as long as it supports common free formats. One popular alternative is *Wings 3D*. Ultimately though, all models have to importable into Blender since we are dependent on the OGRE 3D exporter for it in order to integrate with the rendering engine.
- *Caelum* is a weather generation plugin for the OGRE 3D rendering engine. It is used to provide weather effects wherever necessary on Mars.
- The *CEGUI* library allows graphical user interfaces to be built on top of the *OGRE 3D* rendering engine. This is necessary for the in game graphical user interface. CEGUI user interfaces are defined through Lua scripts accessing its Lua interface.
- *Hydrax* is a fluid dynamics plugin for the OGRE 3D rendering engine. It is used to provide fluid effects wherever necessary on Mars.
- The *OGRE 3D* rendering engine is a powerful, cross-platform, API generally aimed at game developers. It has a rich and simple to use API with a plethora of plugins available for it. It is strictly a rendering engine and does not, however, cover input, audio, and other standard game engine subsystems.
- The *OpenGL* library provides the rendering backend for the OGRE 3D rendering engine. Although the latter supports other backends, it is very difficult to write and maintain shaders for all of them. OpenGL is ubiquitous these days, can do virtually everything Direct3D can, and does not hold you hostage to any specific platform.
- The *OpenGL Extension Wrangler Library* (*GLEW*, helps in querying and loading OpenGL extensions. It provides efficient run-time mechanisms for determining which OpenGL extensions are supported on the target platform. All supported OpenGL extensions are exposed in a single header file, which is machine-generated from the official extension list.
- *Terrain* is another plugin for the OGRE 3D rendering engine allowing for, as the name suggests, terrain generation.

- The *SDL* library is used to provide image and font loading through its *SDL_image* and *SDL_pango* APIs respectively.

7.4 Input

- The *SDL_haptic* API is used for providing force feedback, provided the API is available and the user's input device supports it. SDL version 1.3 or greater is required.
- The *SDL_input* API is used to provide input handling.

7.5 Networking

- The *ENet* library provides the low level library which Avaneya's multiplayer protocol is built upon. Its purpose is to provide a relatively thin, simple and robust network communication layer on top of UDP (User Datagram Protocol). The primary feature it provides is optional reliable, in-order delivery of packets. It omits certain higher level networking features such as authentication, lobbying, server discovery, encryption (which we provide via GnuTLS), or other similar tasks that are particularly application specific so that the library remains flexible, portable, and easily embeddable.
- The *GNU Transport Layer Security Library* (GnuTLS) is a free software implementation of the SSL and TLS protocols. It is used to provide encryption at the application level to make it more difficult for an uninvited third party to be a nuisance.

7.6 Operating System

- *Apport* intercepts program crashes, collects debugging information about the crash and the operating system environment, and sends it to us in a standardized format by integrating directly into Launchpad. It is available only on supported GNU operating systems.
- The *D-Bus* (Desktop Bus) API is a simple inter-process communication (IPC) system for software applications to communicate with one another. Avaneya can use it to determine the state of the user's network connection, among other things. It is available only under supported POSIX compliant operating systems.

7.7 Physics

- *OgreBullet* is a plugin adding physics support to the OGRE 3D rendering engine. It is built upon *Bullet*, a free physics engine featuring 3D collision detection, soft body dynamics, and rigid body dynamics. It is used in games, and in visual effects in movies.

7.8 Scripting

- The *libtolua++* library is used to integrate our C++ code with Lua. It is an updated

replacement to the older toLua tool. It makes it possible for engine code to invoke Lua code, and vice versa.

- *Lua* is used to provide scripting support to the AresEngine. The runtime environment needs to have *package.loadlib* present.
- The *lua-gettext* API is a Lua package that acts as a Lua wrapper for gettext bindings.
- The *lua-xgettext* tool is a small program for message extraction of marked strings from Lua code so they can be made available for translation to other languages. It is similar to *GNU xgettext*, but far more primitive; it just extracts the strings and prints them out, without any additional information. It was written, because GNU ‘xgettext’ did not support Lua at the time.

8 Information For Everyone

8.1 AresPackages

8.1.1 Purpose

The AresEngine uses a custom game archive format built using EBML, an extensible language akin to XML, but tailored to handling binary data. The Matroska multimedia container is its most prominent client.

You might be wondering why a game engine requires its media to be delivered to it in a custom archive format, as opposed to being exposed "naked" directly through the platform's native file system. There are a number of benefits to using a custom archive format, as well as EMBL specifically.

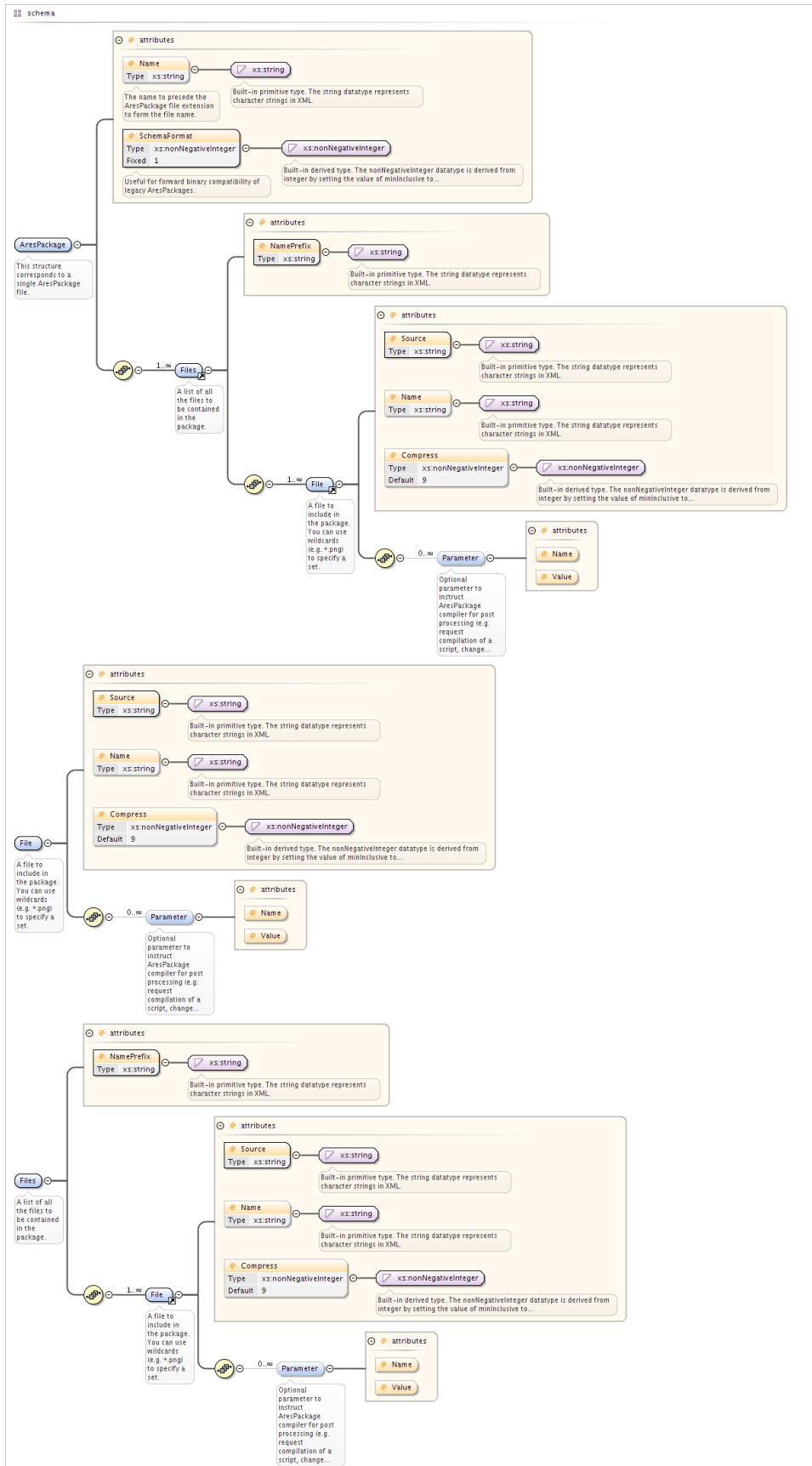
- The EMBL format enables extendability for future format changes.
- It can be easier to distribute a few files containing many, than many to the end user.
- As a single file (*.AresPackage), file seek, open, and load times are reduced.
- Providing a layer of abstraction between the actual raw data and the client that requires it allows us to decompress compressed data on the fly. This results in a smaller file, which means a faster disk to RAM transfer. Remember that the disk is slow, while the CPU is much faster.

8.1.2 Usage

The *ares-package* tool takes a package manifest file (XML) describing the contents of the package to output. The tool archives the requested files, along with whatever settings that may be required, and outputs the package.

8.1.3 Design

A package manifest is checked against an XML schema (AresPackage.xsd) to verify it is syntactically correct. AresSamplePackage.xml is a sample package. The following diagram is a graphical representation of the schema.



9 Information For Engineers

9.1 Coding Standards

Try to abide by the project coding standards whenever possible. It is easier to adapt to a new coding standard in a project when that standard is uniformly applied to it, as opposed to where everyone applies their own. Try to apply the following conventions whenever working in C++, as well as whatever is practical to carry over to shaders, scripts, and elsewhere.

9.1.1 Legal

Headers (*.h), implementations (*.cpp), and other code, as defined under [Chapter 11 \[Licensing Rationale\]](#), [page 52](#), should have prefixed the following legal notice. Adapt the syntax for comments as necessary for the given machine environment (e.g. shader, makefile, etc.).

```
/*
    AresEngine, a 3D game engine.
    Copyright (C) 2011 Kshatra Corp <kip@thevertigo.com>.

    Public discussion on IRC available at #avaneya (irc.freenode.net)
    or on the mailing list <avaneya@lists.avaneya.com>.

    This program is free software: you can redistribute it and/or modify
    it under the terms of the GNU General Public License as published by
    the Free Software Foundation, either version 3 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, see <http://www.gnu.org/licenses/>.
*/
```

9.1.2 Formatting

- Always use spaces and not tabs.
- Each level of nesting should be indented by four spaces. The exception to this is when a prefix operator precedes an identifier, in which case it should be indented so that the identifier begins at a four space interval.

Right:

```
float SomeFunction()
```

```

{
    int i = 0;
    ++i;
    return 1.0f;
}

```

Wrong:

```

float SomeFunction()
{
    int i = 0;
    ++i;
    return 1.0f;
}

```

- You do not need to indent to accommodate a namespace when an entire source file is enclosed within one. If only part of the source is enclosed in a namespace, then those parts affected should be indented.
- An opening brace appears on the next line as preceding code.

Right:

```

float SomeFunction()
{
    for(int x = 0; x < 100; ++x)
    {
        ...
    }
}

```

Wrong:

```

float SomeFunction() {
    for(int x = 0; x < 100; ++x) {
        ...
    }
}

```

- Put spaces around binary operands

Right:

```

A = X + Y;
if(X == Y)
    ...

```

Wrong:

```

A = X+Y;

```



```
if(X==Y)
    ...
```

- There is no space between unary operators and the affected variable's name.
- When accessing an array, there is no space between the array name and the opening left bracket.

Right:

```
int n[100];
y = n[3];
```

Wrong:

```
int n [100];
y = n [3];
```

- The if, for, and while keywords are not followed by a space separating them and the left parenthesis.

Right:

```
if(x == 4)
    return;
```

Wrong:

```
if (x == 4)
    return;
```

- When declaring variables, align the variable names on the same column evenly divisible by four.

Right:

```
int      Count;
bool     Complete;
Window   MainWindow;
```

Wrong:

```
int Count;
bool Complete;
Window MainWindow;
```

- When calling a function, definitions and function declarations should have no space between the function name and the following left parenthesis.

Right:

```
int Add(int a, int b)
{
    ...
}
```

```
int i = Add(4, 5);
```

Wrong:

```
int Add (int a, int b)
{
    ...
}
```

```
int i = Add (4, 5);
```

- When calling a function or making a function declaration, no space appears after the left parenthesis or before the right parenthesis.

Right:

```
foo(x, y);
bar(z);
baz();
```

Wrong:

```
foo( x, y );
bar( z );
baz( );
```

- A brace preceding or following an else keyword appears on the same line as the else. A statement following an else keyword appears on the same line as the else.

Right:

```
if(x == 4)
{
    ...
}
else
    ++y;

if(x == 4)
{
    ...
}
```

```

else
{
    ...
}

```

Wrong:

```

if(x == 4) {
    ...
}
else ++y;

if(x == 4) {
    ...
} else ++y;

if(x == 4) {
    ...
}
else {
    ...
}

```

- A brace preceding a catch keyword appears on a separate line as the catch.

Right:

```

try
{
    ...
}

catch(Error SomeError)
{
    ...
}

```

- A value in a return statement is parenthesized where it contains more than one term.

Right:

```

return x;
return (a + b);

```

Wrong:

```

return (x);
return a + b;

```

- If the body of an if, for, while or similar statement consists of a single statement, the statement does not need to be surrounded by braces.

Right:

```
if(x == 3)
    ++x;
```

9.1.3 Naming

- Do not use Hungarian notation. We prefix objects to denote scope only.

Member of a global namespace:

```
g_Wheels
```

Member of a structure or class:

```
m_Wheels
```

Static member of a structure or class:

```
ms_Wheels
```

- Class and object names should be intuitive, try to avoid abbreviations, and each word should begin with a capital letter. Modern storage mediums can afford to spare brevity, allowing for greater clarity.

Right:

```
// Class for abstracting a camera interface...
class Camera
{
    ...
};

// Create a camera...
Camera LogitechCamera;
```

Wrong:

```
class cam
{
    ...
};

cam log;
```

9.1.4 Structure

- Source lines may be up to 100 characters long. (You can configure gedit to display a margin at 100 characters; that may help you follow this convention.)

- Functions or methods should be broken down into other functions or methods if they get too long and this is reasonable to do.
- Use *assert()* to check your assumptions for things that ought to always be true. Do not abuse it for situations where it is reasonable for a condition to not be true, such as a socket connection failure or a file that could not be opened.
- Follow the *GNU Coding Standards* as much as reasonably possible, save the code formatting points made in this handbook. There is a great deal of wisdom in it.
- A comment which indicates task which needs to be done at some point should look like this:

```
// TODO: Check portability here...
```

9.1.5 Comments

- All comments should be written in English since nearly all programmers in all countries can read that. If you cannot do that, write them as best you can and have someone help you rewrite them.
- Comments should begin with a single space, then a capital letter and end with a trailing ellipses.

Right:

```
// Load the image...
GrayImage = cvLoadImage(Path.mb_str(), CV_LOAD_IMAGE_GRAYSCALE);
```

Wrong:

```
GrayImage = cvLoadImage(Path.mb_str(), CV_LOAD_IMAGE_GRAYSCALE); //load the image.
```

- The farther left the comment, the higher level and abstract what you are trying to do is. The farther right, the more detailed they are. You can think of a given level of indentation as elaborating on how to carry out what was described at a higher (less indented) level. It should be possible in many cases to strip away all the code, except the comments, and still understand what it is that you were trying to do.

Before:

```
// Analyze single image...
void AnalysisThread::AnalyzeImage(wxString Path)
{
    // Variables...
    IplImage *GrayImage = NULL;
    wxString TempString;
```

```

// Reset the tracker, if not already...
Frame.Tracker.Reset(0);

// Load the image...
GrayImage = cvLoadImage(Path.mb_str(), CV_LOAD_IMAGE_GRAYSCALE);

// Failed to load media...
if(!GrayImage)
{
    // Alert...
    wxLogError(wxT("Unable to load image."));

    // Abort...
    return;
}

// Feed into tracker...
Frame.Tracker.Advance(pGrayImage);

// Cleanup gray image...
cvReleaseImage(&GrayImage);
}

```

Stripped:

```

// Analyze single image...

// Variables...

// Reset the tracker, if not already...

// Load the image...

// Failed to load media...

// Alert...

// Abort...

// Feed into tracker...

// Cleanup gray image...

```

- A single blank line should appear between each pair of functions or methods.
- Do not use a blank line after an opening brace or before a closing brace.

- Do not use duplicate blank lines.

9.1.6 Developer Tools

You are welcome to use any editor or IDE you like, provided it does not require non-standard IDE-specific project files. See [Section 7.2 \[Dependent Technology Developer Tools\]](#), page 11 for a list of all of the developer tools that are required for the project.

9.2 Architecture

The *AresEngine* is responsible for delivering Avaneya. It is designed by the Avaneya crew to provide for the game, but kept architecturally general enough to lend itself to other projects of similar technical requirements (e.g. a city builder / real time strategy genre). If you do not know what a game engine is, Jason Gregory's book *Game Engine Programming*,¹ is highly recommended.

The AresEngine is divided up into many subsystems, each responsible for a given logical task. These include audio, responding to input devices, updating the graphical user interface, artificial intelligence, and so on.

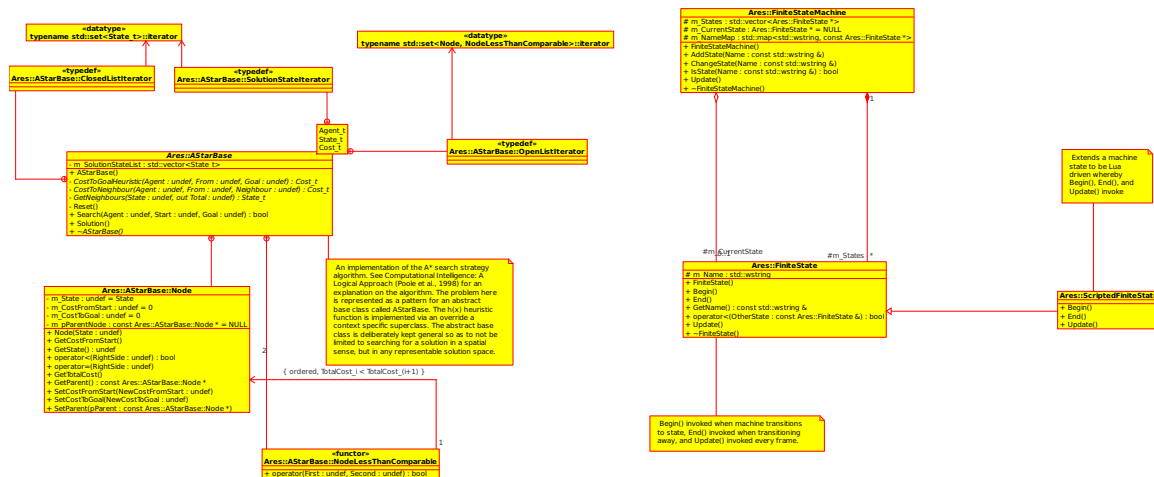
Umbrello was used to come up with the architectural design. At this time, you may need to use the latest Umbrello built from source because the task at hand was so demanding, only Umbrello's bleeding edge was able to handle it. Unfortunately the pre-compiled binary available in most distributions had many show stopper bugs in it that would have made work impossible. Even building from source, it still has many problems. Nevertheless, it was the most mature and functional free design tool available at the time and may still be. We are very grateful to the Umbrello crew who were especially helpful in fixing bugs as they were discovered through the engine design stress testing it.

The following architectural diagrams were pulled from the AresEngine's Umbrello project file automatically at the time this handbook was compiled on 5 May 2011.

¹ See [\[Resources for Engineers\]](#), page [\[undefined\]](#) for details.

This diagram concerns itself with useful artificial intelligence algorithms, though not of an entire subsystem itself.

It contains an implementation of the A* search strategy algorithm.¹ The problem here is represented as a pattern for an abstract base class called *AStarBase*. The $h(x)$ heuristic function is implemented via an override a context specific superclass. The abstract base class is deliberately kept general so as to not be limited to searching for a solution in a spatial sense, but in any representable solution space (e.g. time, language, etc.).



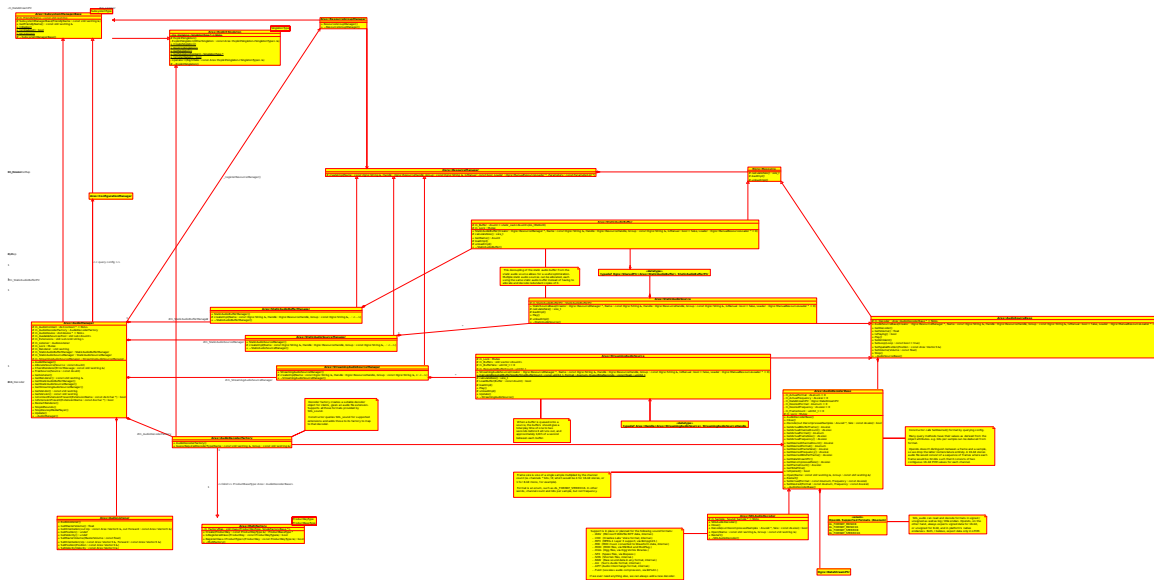
¹ See *Computational Intelligence: A Logical Approach*, Poole et al., 1998 for an explanation on the algorithm.

9.2.2 Audio

The *AudioManager* subsystem is responsible for all tasks related to audio. Audio playback is divided into streaming and static audio sources. Streaming sources need to be continuously updated by loading new data from disk, decompressing it, and playing it. A common example would be music or narrative. Static sources are usually smaller and only need to be played once before being freed. Static source examples would be things like the sound of an object contacting another.

Decoding is done through an appropriate subclass of an *Ares::AudioDecoderBase* abstract class, instantiated via the *Ares::AudioDecoderFactory* class. Most decoding is done through a subclass of the aforementioned via *SDL_audio*.

Playback is accomplished through OpenAL.

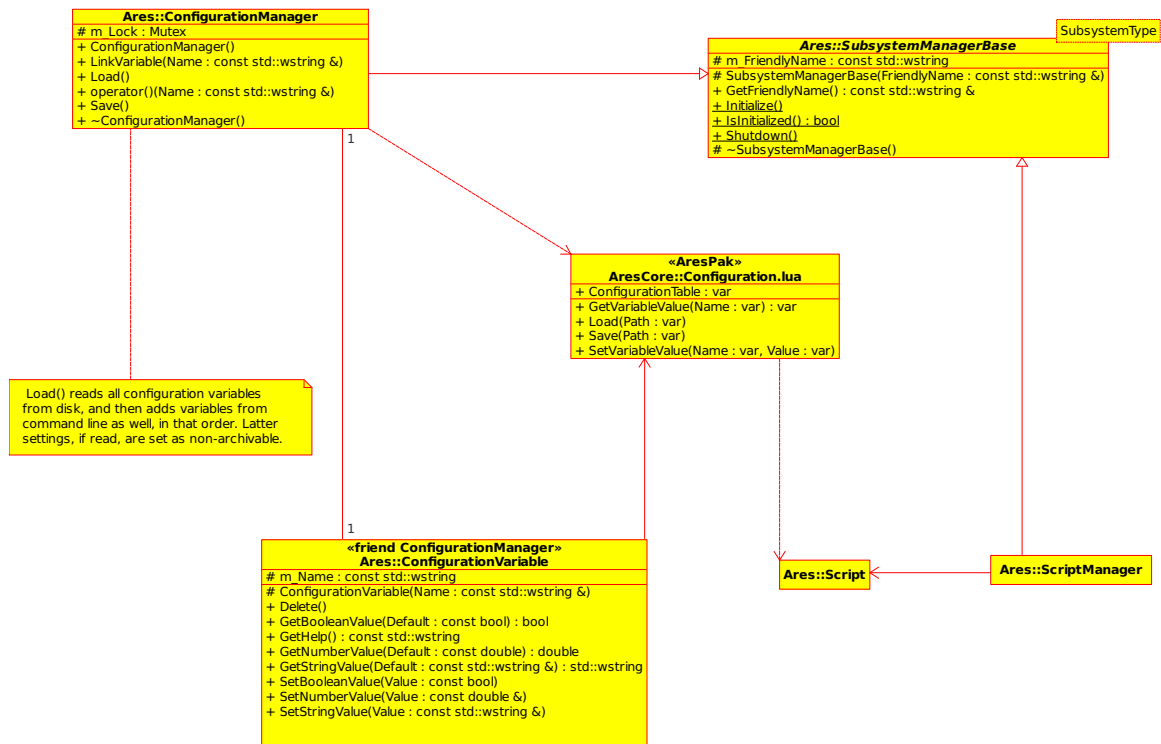


9.2.3 Configuration

The *ConfigurationManager* subsystem is responsible for storing all user configuration. Its *Load()* method reads all configuration variables from disk, and then adds variables from command line as well, in that order.

Latter configuration variables read are set as non-archivable. A non-archivable configuration variable is one that is not saved to disk.

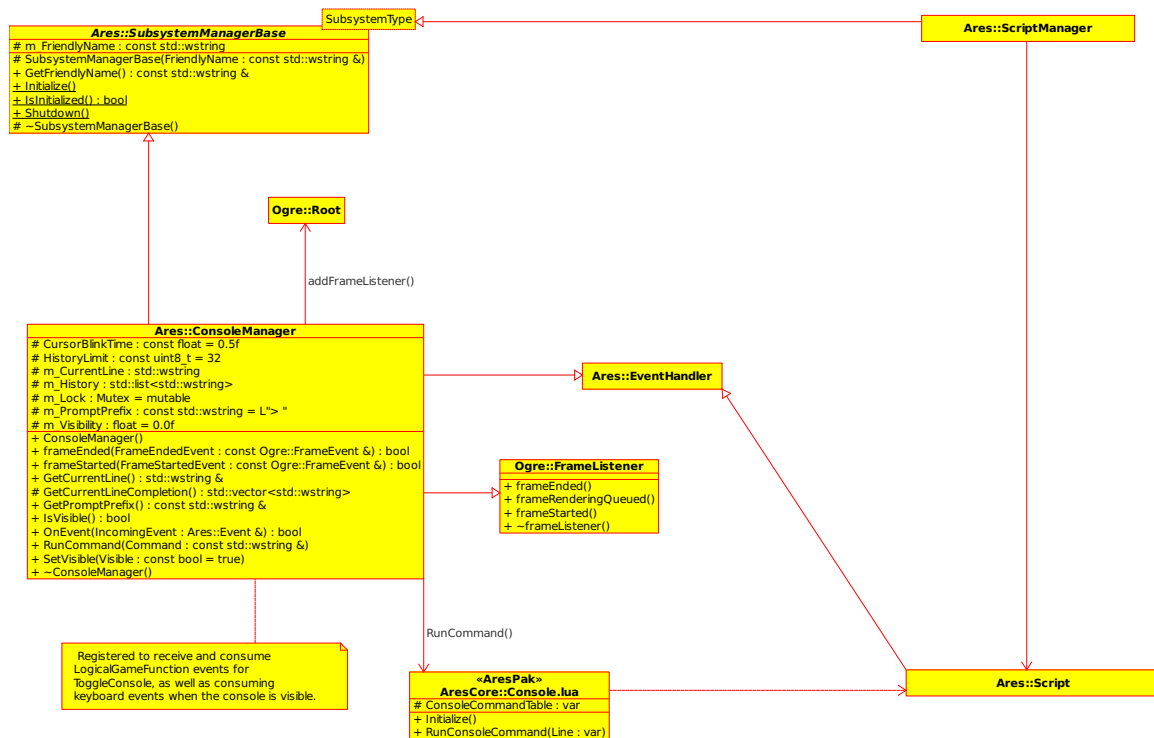
Much of the manager is implemented in Lua because of its excellent database handling.



9.2.4 Console

The in game console allows users to access aspects of the game engine at runtime. This is useful for debugging or other purposes.

Console commands are implemented in Lua.

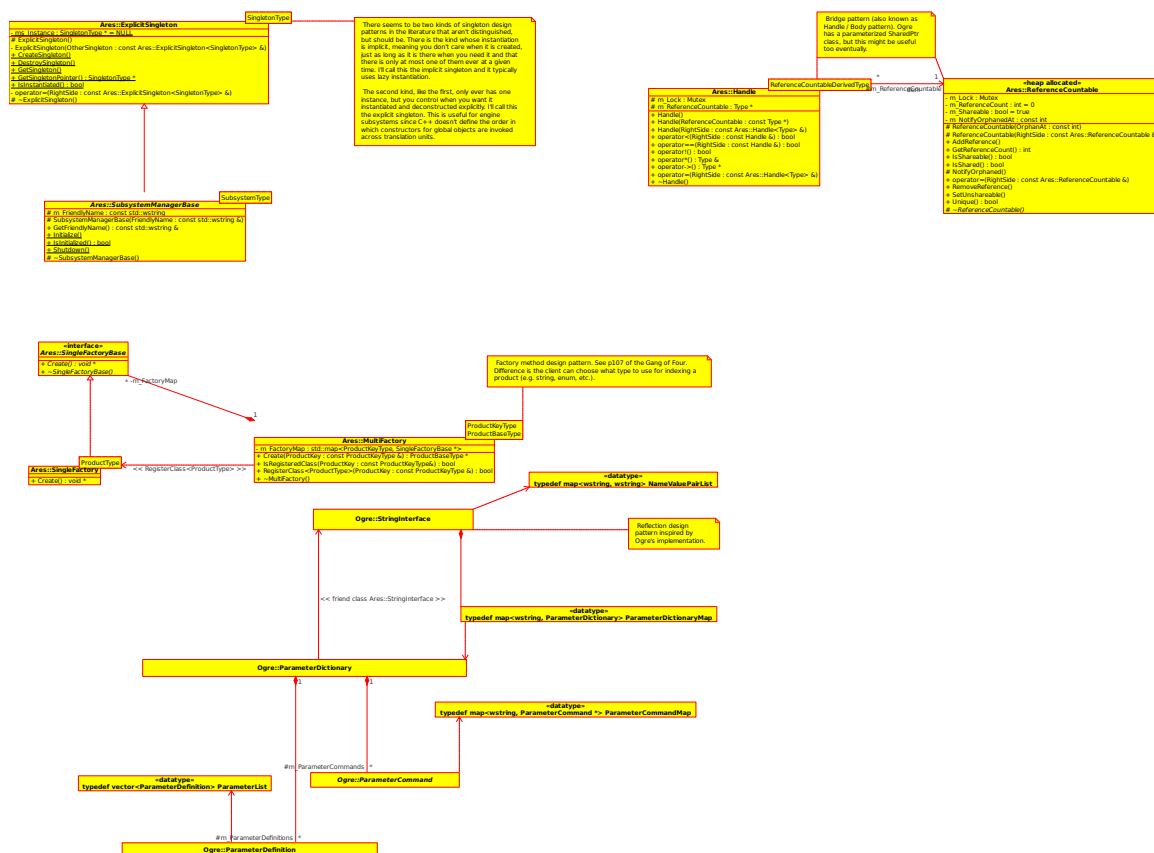


9.2.5 Design Patterns

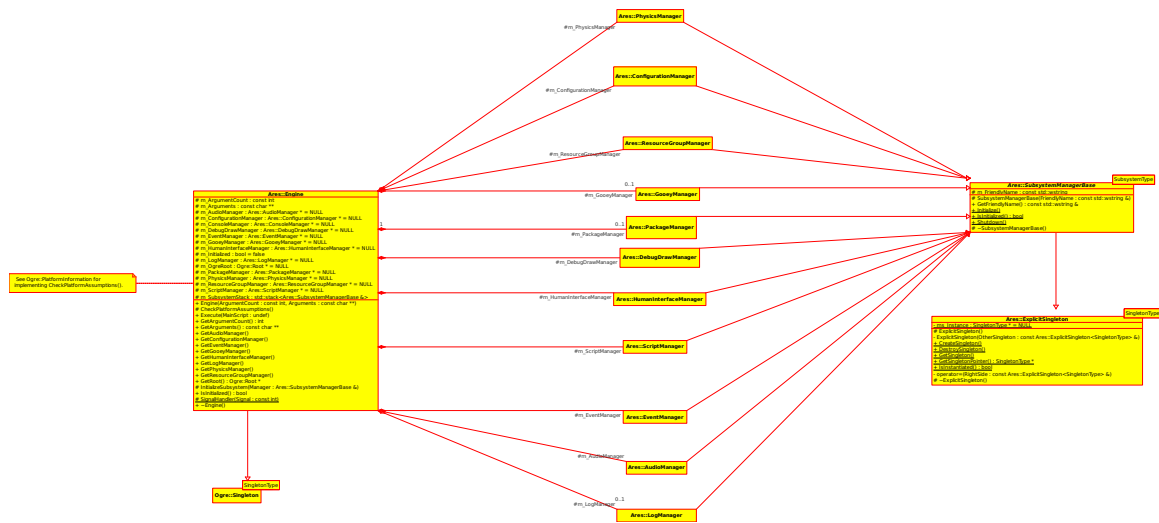
This diagram contains a number of common place design patterns found in many software projects, such as the singleton and multi-factory.

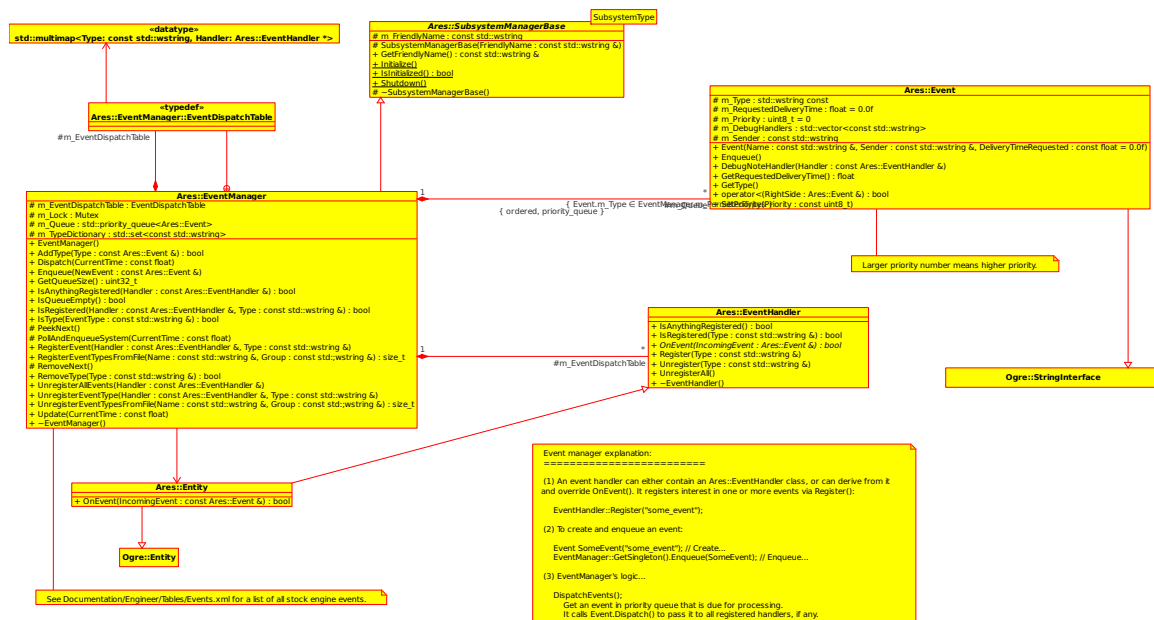
There seems to be two kinds of singleton design patterns in the literature that are not distinguished, but should be. There is the kind whose instantiation is implicit, meaning you don't care when it is created, just as long as it is there when you need it and that there is only at most one of them ever at a given time. We refer to this as the *implicit singleton* and it typically uses lazy instantiation.

The second kind, like the first, only ever has one instance, but you control when you want it instantiated and deconstructed explicitly. We refer to this as the *explicit singleton*. This is useful for engine subsystems since C++ does not define the order in which constructors for global objects are invoked across translation units. This is important to consider, given that the order of subsystem initialization is very important (e.g. resource management must precede audio management).

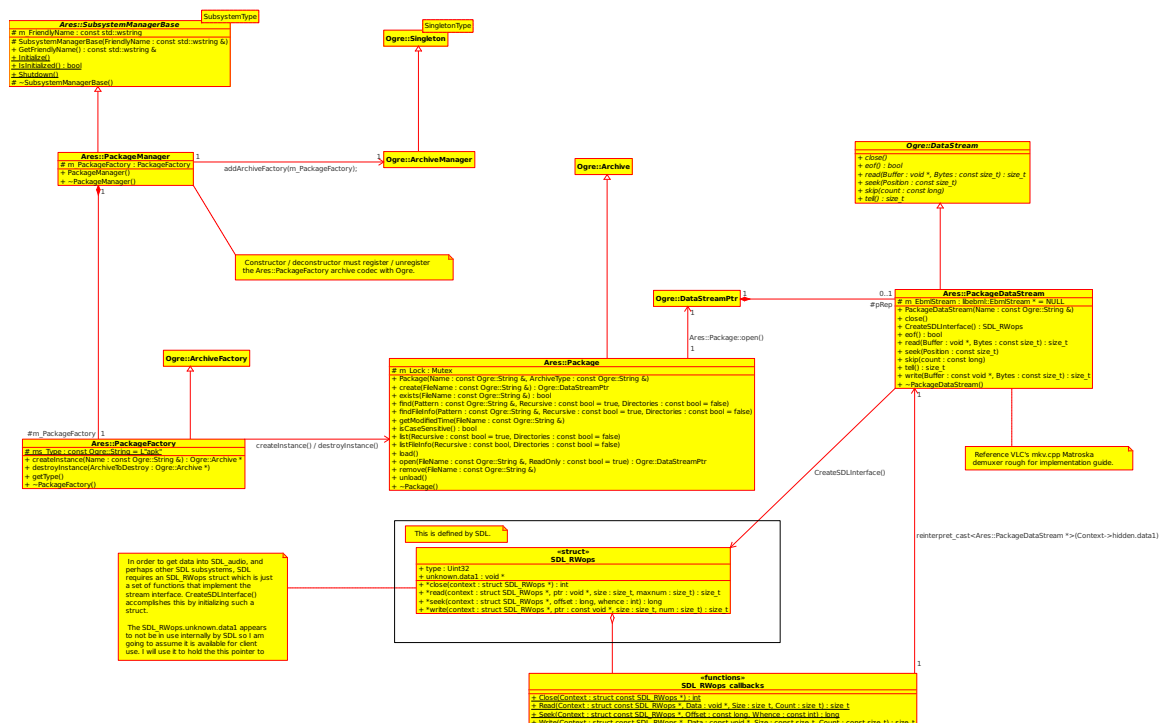


This diagram captures the engine at the highest level and provides an overview of all components in the most abstract sense.





Accessing files on disk for textures, shaders, scripts, models, sounds, and so on, requires an intermediary in most game engines. The AresEngine is no different. Files are stored inside of an EBML encoded container format called an AresPackage. The EBML format was selected because it enables extendability for future format changes and allows arbitrary metadata. It also has performance advantages because only a single file (*.AresPackage) needs to be located for a group of files contained within. This reduces file seek and access times. Also, because the AresPackage files can be compressed, it means that they take less time to access their payload because transferring a small file from disk and decompressing in RAM is faster than transferring a large uncompressed file from disk to RAM.



9.2.9 Gooney

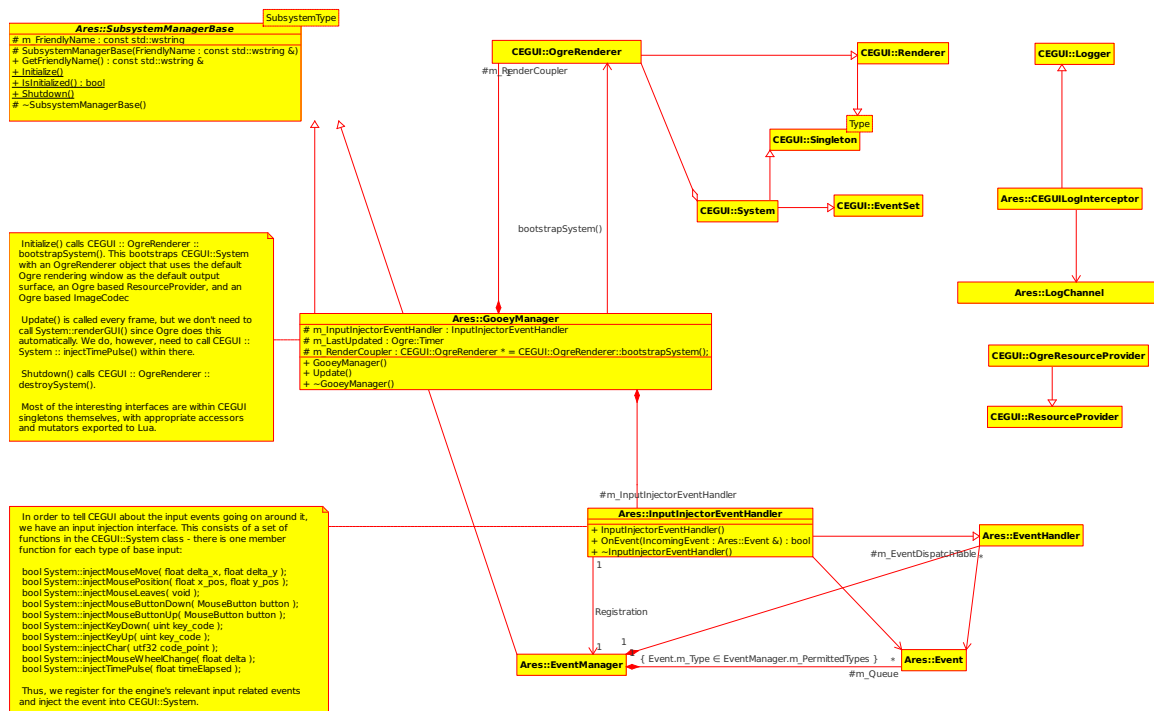
The *GooneyManager* is responsible for managing all graphical user interface overlays and user interaction with them. Its underlying functionality is provided by CEGUI which integrates well into OGRE 3D.

GooneyManager::Initialize() calls *CEGUI::OgreRenderer::bootstrapSystem()*. This bootstraps *CEGUI::System* with an *OgreRenderer* object that uses the default Ogre rendering window as the default output surface, an Ogre based *ResourceProvider*, and an Ogre based *ImageCodec*.

Update() is called every frame, but we do not need to call *System::renderGUI()* since Ogre does this automatically. We do, however, need to call *CEGUI::System::injectTimePulse()* within there.

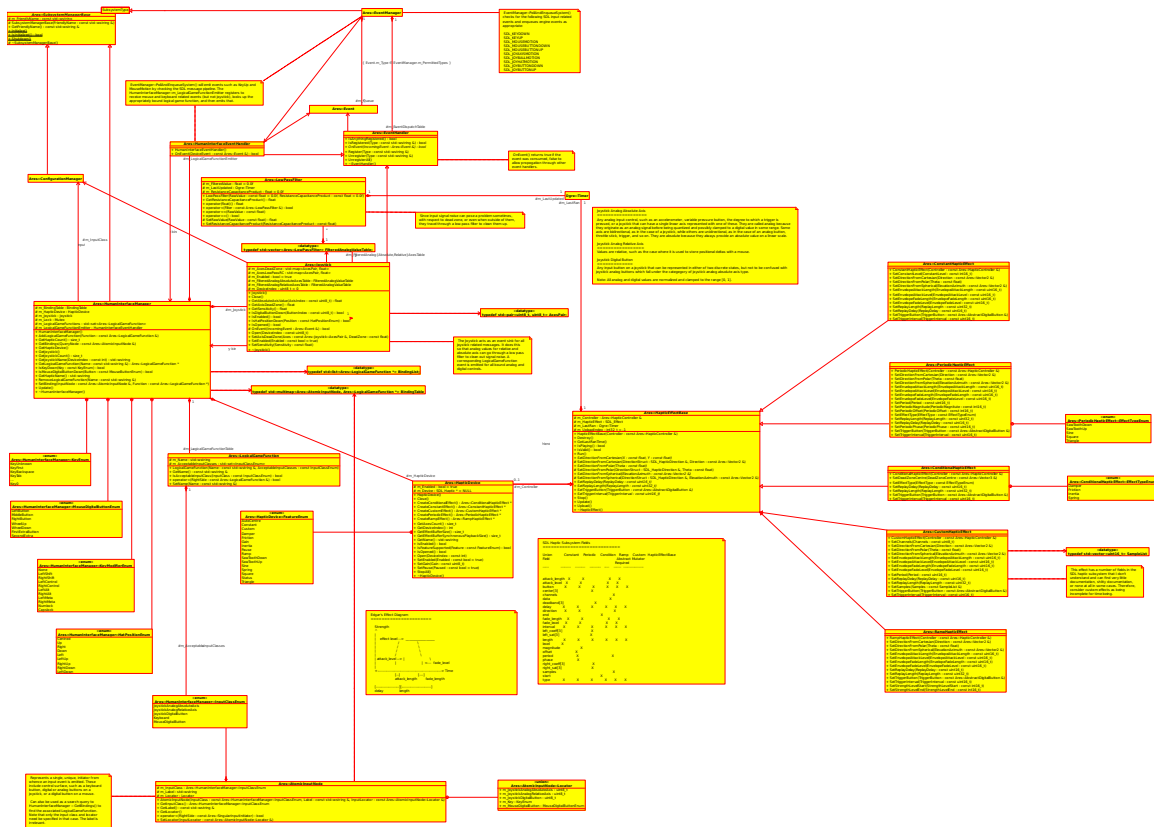
Shutdown() calls *CEGUI::OgreRenderer::destroySystem()*.

Most of the interesting interfaces are within CEGUI singletons themselves, with appropriate accessors and mutators exported to Lua.

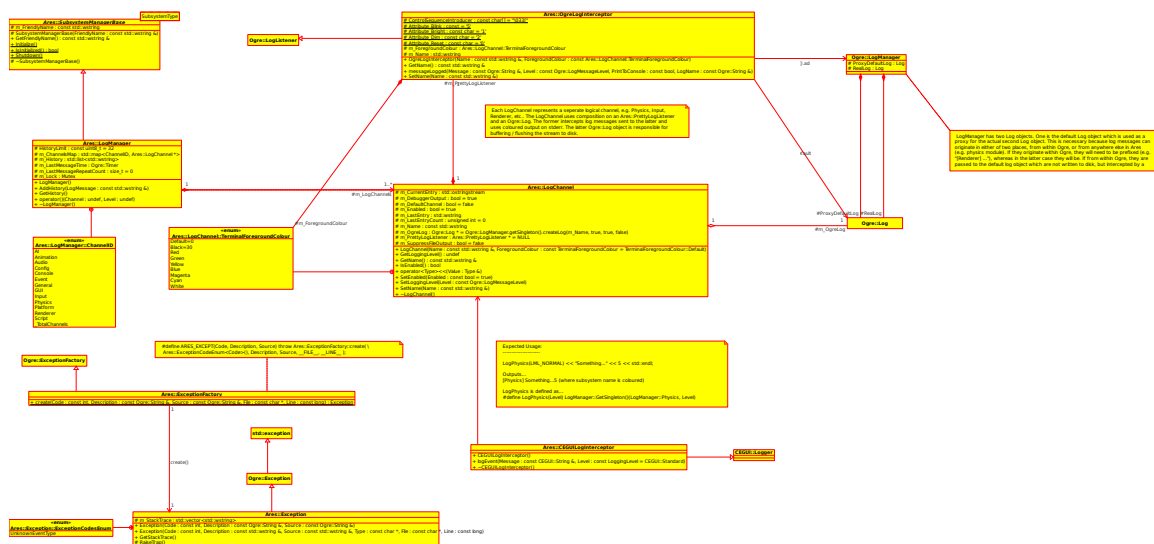


9.2.10 Human Interface

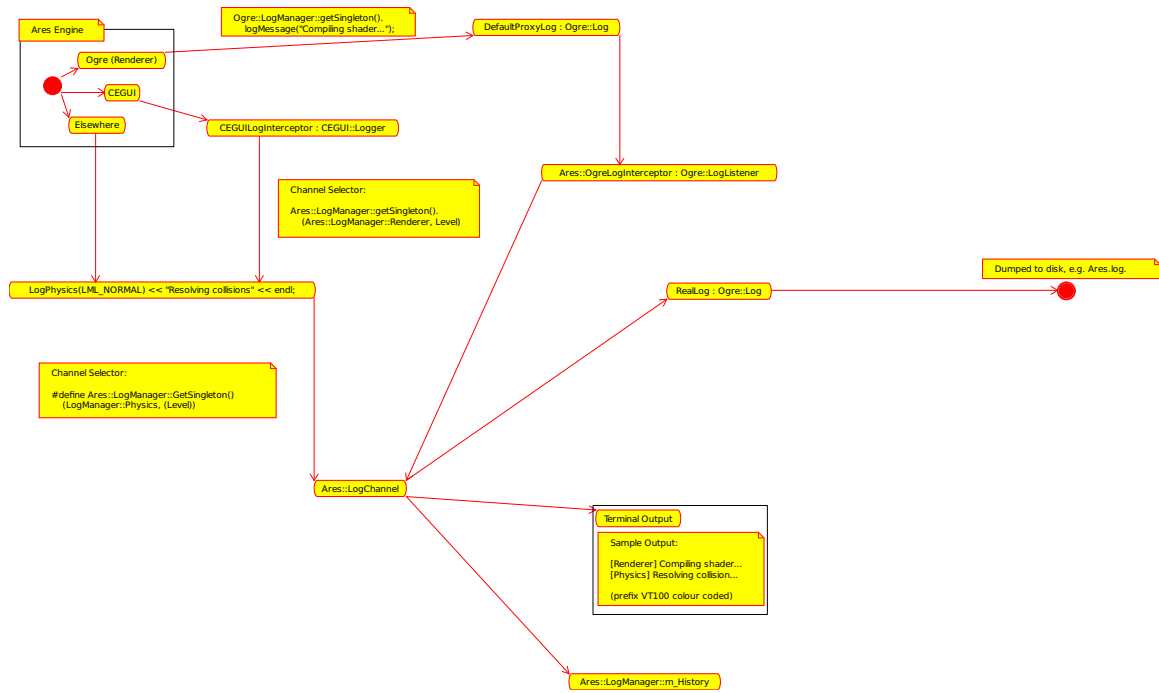
The *HumanInterfaceManager* takes care of routing all events from input devices to the appropriate code that has registered to be notified of that event. In that sense, the manager is mostly unidirectional, but also allows to send information the other way back to the input device if it supports a haptic interface (sometimes called force feedback).



The *LogManager* is responsible for providing a central logging subsystem for all the other subsystems.

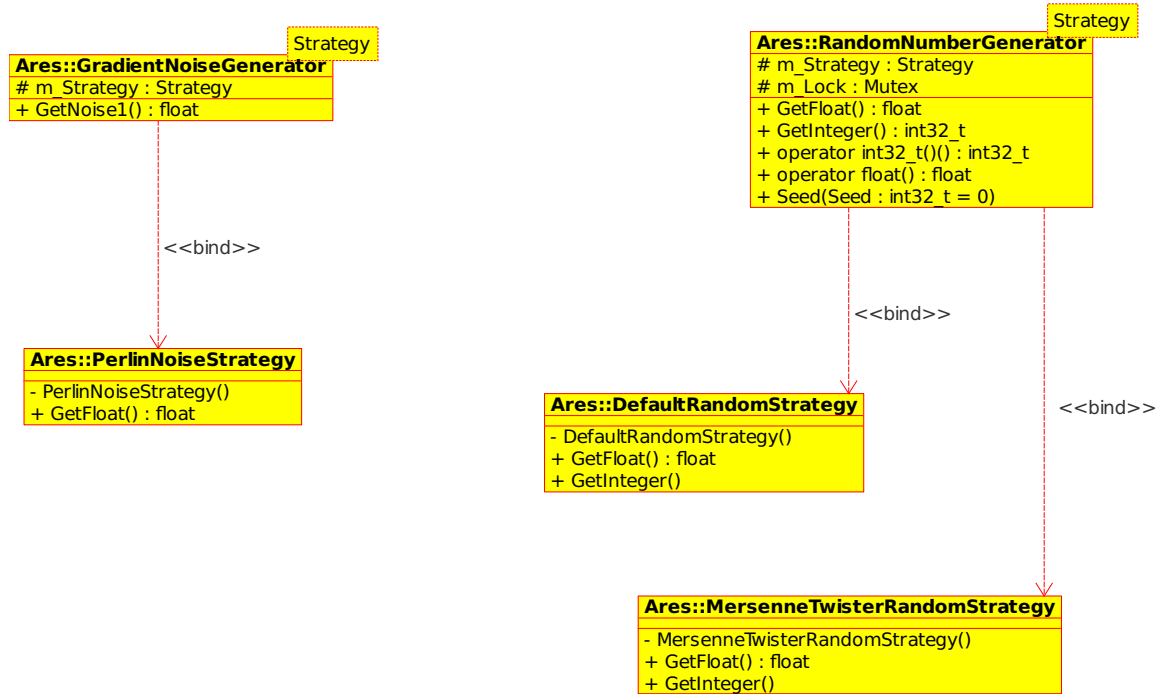


Since message can be emitted from any number of places, such as within the engine, or within some other externally linked component, such as CEGUI or OGRE, messages have to be intercepted and channeled through the *LogManager*. The following diagram makes this more clear.



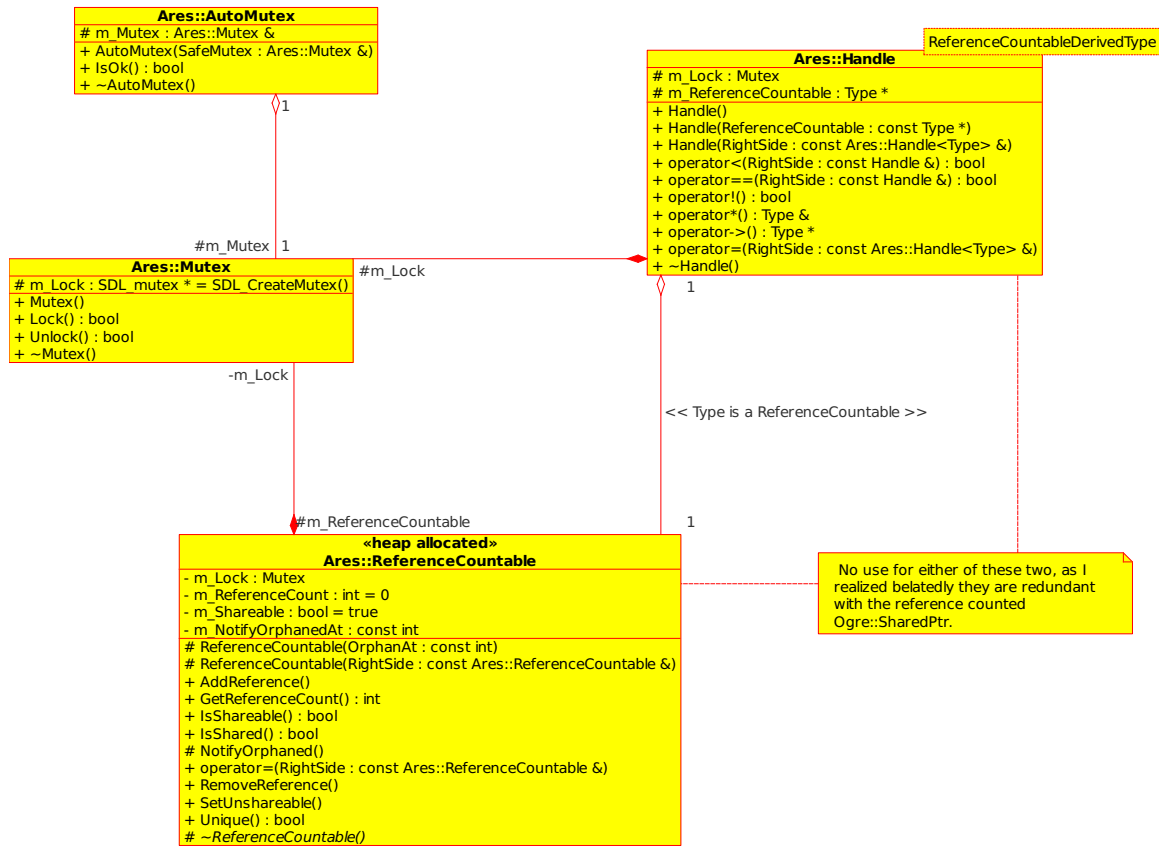
9.2.12 Mathematical

Most mathematical routines for matrices and other linear algebra are provided by OGRE 3D. Some things like more advanced random number generation have to be implemented ourselves here.

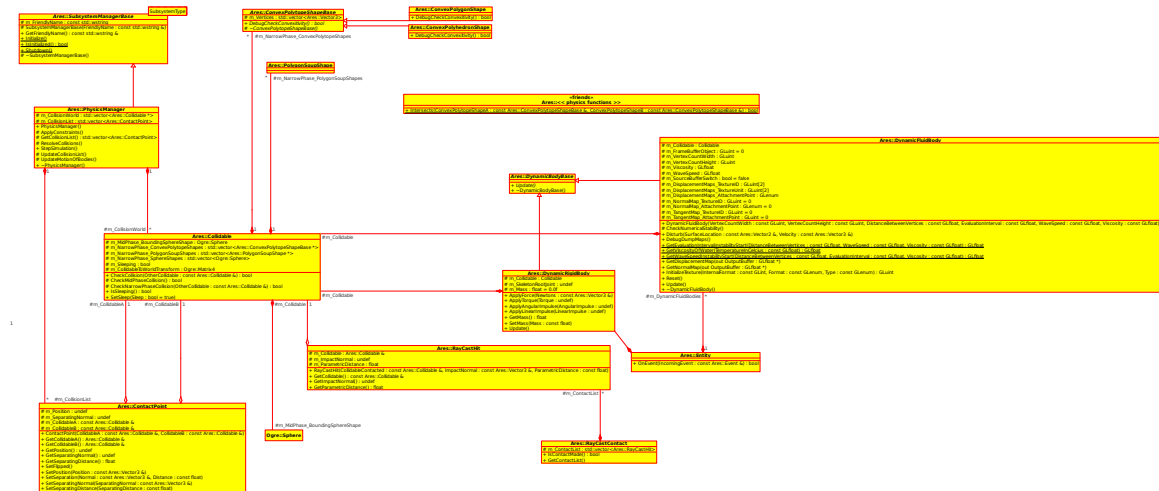


9.2.13 Miscellaneous

This is a catch-all for classes and functions that had no business elsewhere.

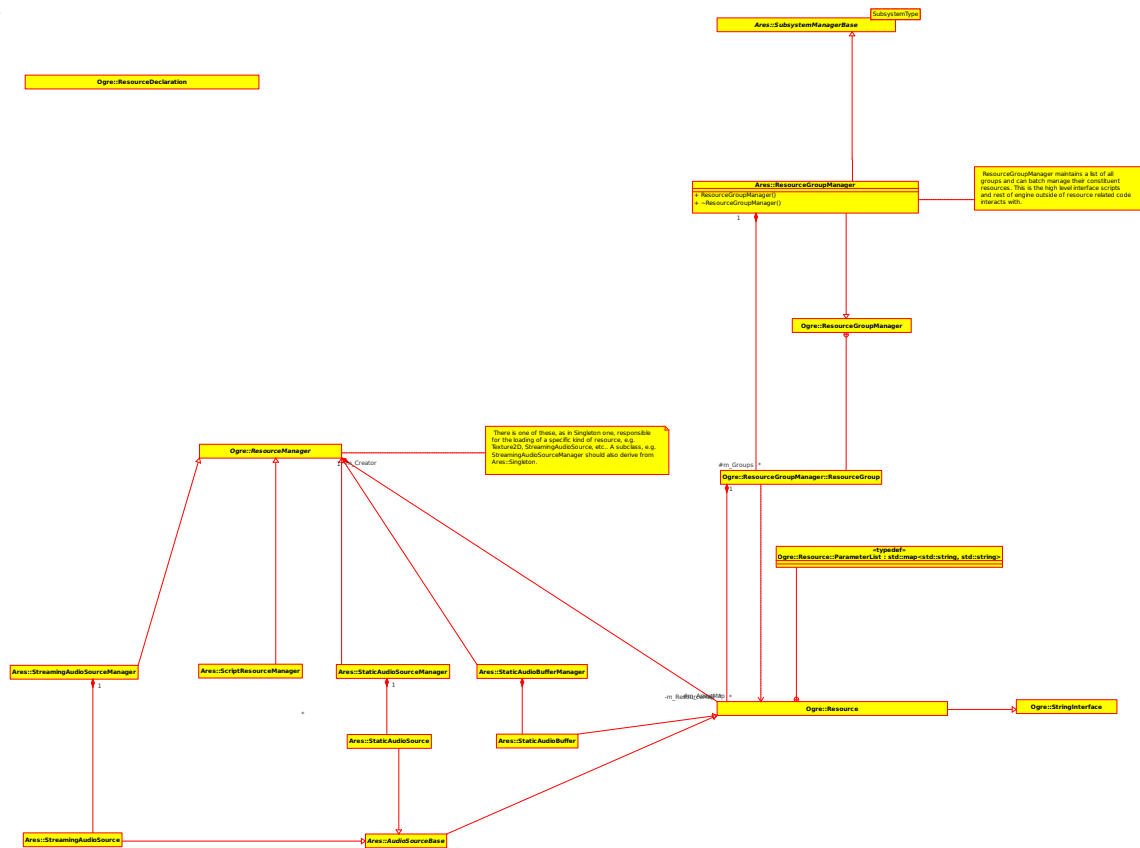


The *PhysicsManager* needs to be seriously refactored since *OgreBullet* was found as a viable option for physics support. This is the original, incomplete, design before that decision was made.



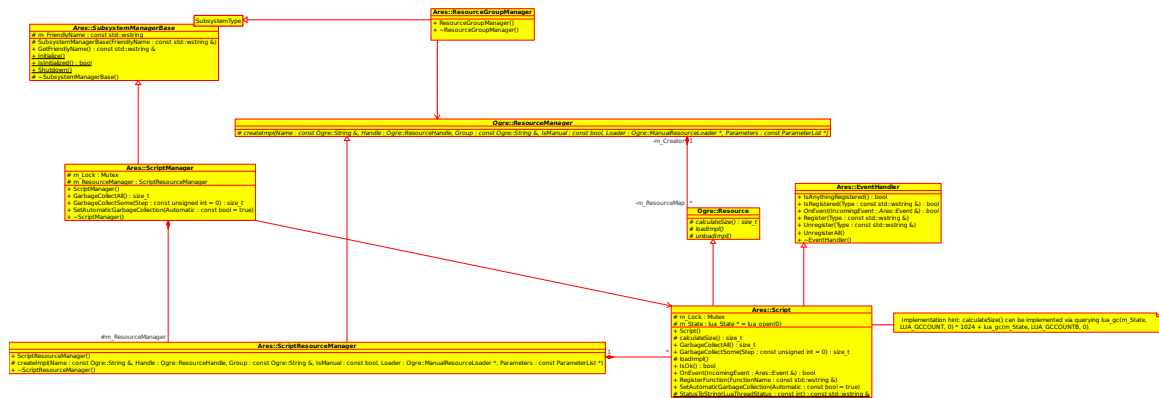
9.2.15 Resources

The *ResourceManager* is responsible for ensuring that whenever code needs a piece of game data, such as a model or animation, all of its requisites are loaded, in the correct order, only once, and take up only as much room as they absolutely must. The *ResourceManager* and the *FileManager* communicate to help the former locate what it needs physically on disk.



9.2.16 Scripting

The *ScriptManager* is responsible for exposing all useful aspects of the game engine to the game scripters. Since the engine itself is defined in code, the role of defining what makes Avaneya, Avaneya, is left to script writers.



10 The Project Crew

10.1 If You Are New

If you are new to the Avaneya crew, welcome! You will probably enjoy working on the project and the sense of community *software libre* projects tend to create. To get you started, here are a couple things you should probably do as soon as you can.

1. Read this handbook, which you are already doing.
2. Get on the low volume announcement mailing list. See [Section 10.5.1 \[Mailing Lists\]](#), [page 47](#) for details.
3. Join the Avaneya Crew on Launchpad. Membership requires approval. If you already received an invite, great. Otherwise, feel free to ask us. There is lots of room in the project for more talent. See [Section 10.5.3.1 \[Launchpad Crew\]](#), [page 49](#) for details.
4. Also join the private discussion mailing list at the aforementioned link. Once on, I recommend you email the list and let everyone know a bit about yourself. They are all good people and will be happy to see a new face. You will be joining fellow musicians, engineers, and artists. See [Section 10.5.1 \[Mailing Lists\]](#), [page 47](#) for details.

10.2 Specialities

Avaneya is a fairly large, creative, and collaborative project, calling upon a variety of different disciplines. These are the different capacities Avaneya contributors fall into. There is no reason why someone who wishes to work in more than one capacity cannot. Many do so already.

2D Artist 2D artists work on the graphical user interface managed by cegui, texturing for models, and other things of that sort. Their areas of expertise range from conceptual art, storyboarding, font design, bump maps, and procedural textures (materials). They can work with a range of software from FontForge to GIMP.

Audio Engineer

These folks creatively can take unassuming sounds and transform them into things usable for science fiction game. An example would be sampling the squeak of a chair or a car driving by with a high end portable recorder and remixing it into the sound of a nuclear electric ion-drive propulsion system. You might find them working with software like Ardour, Rosegarden, and portable high resolution audio recorders.

Cinematic Artist

Cinematics play an important role in games. They prepare the user and set the stage in ways that would be difficult to do during normal game play. They work with tools like Blender, Cinelerra, and Lombard.

- Engineer* The engineers design, discuss, and implement the engine specification, along with writing the Lua script that drive the engine. They work mostly in the languages of C++ and GLSL. The GNU Autotools is useful in the way construction scaffolding is, and they depend on it to ensure the software stays as versatile as possible. There may be some opportunities for assembly level optimizations, but they largely work at a higher level of abstraction that the OGRE 3D rendering engine expects. They coordinate their work with the rest of the team via Bazaar and take care of distribution of pre-compiled binaries via packaging (e.g. debs).
- Modeller* Modellers produce the 3D game models the user sees during game play. They also work with the 2D artists to ensure models are properly textured. They work with Blender, Wings 3D, or any other modelling program that supports standard patent free model formats.
- Musician* The musicians create either new or provide existing tracks for the game. The music falls into two categories. The first is in game ambient music that the user passively listens to. The second is music that is more actively listened to during navigation menus, cinematics, and possibly the separately to be released game soundtrack.
- Researcher* These people provide the background information and attention to detail that makes the game rich. They have an interest in *areology* (the study of Mars), terraforming, simulation and complex modelling, social and political issues (e.g. the *Genuine Progress Indicator*), and whatever else that might be useful.
- Scripter* Scripters write code in Lua that drives and breathes life into the game engine. They will probably work with the engineers to ensure the functionality they require of the AresEngine is exposed safely.
- System Administrator* System administrators run and administer the user forum, moderate the IRC chatroom, monitor the bug tracker on Launchpad, and so on.
- Translator* Translators are what makes Avaneya available to people of different languages. They ensure cinematic subtitles and the game's GUI, and website, are properly internationalized. They work with any tools that support standard GNU gettext and language catalogues.
- Voice Actor* Cinematics and in game audio often requires real people to play a role.

Web Developer

Web developers are familiar with standards and work with things like CSS, XHTML, php, MySQL, and so on. They probably will end up coordinating with the system administrators.

Writer

Writers work closely with the researchers and other artists to provide dialogue and scripts for storyboarding and other game media.

10.3 Avaneya Code of Conduct

Version 1.0

Copyright © 2011 Kshatra Corp.

This Code of Conduct covers our behaviour as members of the Avaneya Community, in any forum, mailing list, wiki, web site, IRC channel, install-fest, public meeting or private correspondence. Avaneya governance bodies are ultimately accountable to the project lead and will arbitrate in any dispute over the conduct of a member of the community.

- **Be transparent, but don't be reckless.** This is a free software project and so we must work as transparently as possible. Having said that, no one likes to have the ending of a good film revealed to them before they have had a chance to see it for themselves. Don't reveal any elements of the storyline or game until it has been discussed and you have been given permission to do so. The crew mailing list is not open to the public and is reserved for Avaneya crew only. Topics range from game storyline spoilers, unreleased conceptual art, security vulnerabilities, and so on. What goes on in this list stays in this list.
- **Be considerate.** Our work will be used by other people, and we in turn will depend on the work of others. Any decision we take will affect users and colleagues, and we should take those consequences into account when making decisions. Avaneya may one day have millions of users and thousands of contributors. Even if it's not obvious at the time, our contributions to Avaneya will impact the work of others. For example, changes to code, infrastructure, policy, documentation, and translations during a release may negatively impact others' work.
- **Be respectful.** The Avaneya community and its members treat one another with respect. Everyone can make a valuable contribution to Avaneya. We may not always agree, but disagreement is no excuse for poor behaviour and poor manners. We might all experience some frustration now and then, but we cannot allow that frustration to turn into a personal attack. It's important to remember that a community where people feel uncomfortable or threatened is not a productive one. We expect members of the Avaneya community to be respectful when dealing with other contributors as well as with people outside the Avaneya project and with users of Avaneya.
- **Be collaborative.** Collaboration is central to Avaneya and to the larger free software community. This collaboration involves individuals working with others in teams within Avaneya, teams working with each other within Avaneya, and individuals and teams within Avaneya working with other projects outside. This collaboration reduces redundancy, and improves the quality of our work. Internally and externally, we should always be open to collaboration. Wherever possible, we should work closely with dependent upstream projects and others in the free software community to coordinate our technical, advocacy, documentation, and other work. Our work should be done as transparently as possible, without ruining the elements of storytelling, and we should involve as many interested parties as early as possible. If we decide to take a different

approach than others, we will let them know early, document our work and inform others regularly of our progress.

- **When we disagree, we consult others.** Disagreements, both social and technical, happen all the time and the Avaneya community is no exception. It is important that we resolve disagreements and differing views constructively and with the help of the community and community processes when necessary.
- **When we are unsure, we ask for help.** Nobody knows everything, and nobody is expected to be perfect in the Avaneya community. Asking questions avoids many problems down the road, and so questions are encouraged. Those who are asked questions should be responsive and helpful. However, when asking a question, care must be taken to do so in an appropriate forum.
- **Step down considerably.** Members of every project come and go and Avaneya is no different. When somebody leaves or disengages from the project, in whole or in part, we ask that they do so in a way that minimises disruption to the project. This means they should tell people they are leaving and take the proper steps to ensure that others can pick up where they left off.

The Avaneya Code of Conduct is an adaptation of the Ubuntu Project's Code of Conduct, also licensed under the [Creative Commons Attribution-Share Alike 3.0](#) licence. You may re-use it for your own project, and modify it as you wish, just please allow others to use your modifications. Remember to give credit to the Ubuntu Project.

10.4 Current Members

10.5 Communication and Coordination

The team uses two primary means of intercommunicating. The first is through the crew mailing list, and the second is over IRC. The Code of Conduct applies to both. See [Section 10.4 \[Code of Conduct\]](#), page 47.

10.5.1 Mailing Lists

Mailing lists have been around for literally decades. They lack the cosmetics and ease of use of a forum, but until our website is ready, it will suffice for the time being.

Avaneya has three mailing lists. The first is a unidirectional announcement mailing list. It is low volume and only intended to communicate from the project to the general public about major project press releases. Anyone can subscribe to it.

Subscribe:

<https://www.avaneya.com/lists/?p=subscribe&id=1>

Browse the archives:

<https://www.avaneya.com/news/announcements/>

The second avaneya@lists.avaneya.com is for anyone to discuss anything related to the project. It is open to everyone.

Subscribe:

<http://lists.avaneya.com/listinfo.cgi/avaneya-avaneya.com>

Browse the archives:

<http://lists.avaneya.com/pipermail/avaneya-avaneya.com/>

The third avaneya-private@lists.avaneya.com is open only to project crew. Topics range from game storyline spoilers, unreleased conceptual art, security vulnerabilities, and so on. If you are a volunteer, you should have been sent a subscription invitation.

Subscribe:

<http://lists.avaneya.com/listinfo.cgi/avaneya-private-avaneya.com>

Browse the archives:

<http://lists.avaneya.com/private.cgi/avaneya-private-avaneya.com/>

When using either of the latter two mailing lists, you may find the following tips useful.

- Do not ever send HTML email. Some peoples' mail clients cannot render it. And even if they can, there is no guarantee it will come out the same. People with visual disabilities may not have their speech synthesizers work properly, since HTML email is much harder to parse. Others may have to pay for additional bandwidth to retrieve your email, since HTML email is larger in size than plain text.¹
- When you reply to a post, remember to reply to the list and not just the original sender privately. Unless you had intended to, the mailing list is setup so that everyone who subscribes to it may benefit from productive communication on it. Sometimes this may not happen until years later when a new subscriber searches through old archives to find a solution to a problem they were having that was solved long ago.
- When replying to a post, if you have your subscription configured to use batch digest mode,² you do not need to copy the whole digest. Just quote the minimum needed for context.
- Check the subject heading of your reply to a message posted on the list to make sure it still reflects the original post. Some mail readers, if you have batch digest mode enabled in your subscription, will change the heading to reflect the batch digest's subject heading, instead of the specific message within it you are replying to.

¹ For more information, consider reading <http://www1.american.edu/cas/econ/htmlmail.htm>

² When batch digest mode is enabled, the server will "batch" together emails into groups and then send it to you as a single compilation to cut down on the amount of email you receive.

- When you reply, remember to reply at the bottom and not at the top of the message. Top posting is generally not encouraged because it makes preservation of chronological order difficult to follow for readers.³

10.5.2 Internet Relay Chat (IRC)

IRC is among the oldest forms of realtime chat over the internet. Avaneya has a channel (**#avaneya**) on the Freenode server (**irc.freenode.net**). You can use whatever client you like, but it is recommended you use one that supports SSL.

Make sure you register your chosen nick name with the *nickserv* on Freenode. This ensures you are consistently identifiable to others in the chat room.

Whenever you would like to send someone a message publicly in the channel, you should precede your message with their nick name. This is because many people have their IRC clients configured to alert them audibly when that happens, as opposed to every time anyone says anything in the channel. Usually you only need to type the first few letters of their nick name and hit tab to have your client complete it.

10.5.3 Launchpad

Launchpad is a project started by Canonical, the company behind the Ubuntu project. It is an online service that allows for coordinated software project collaboration. It provides services for source control management, blueprints, support, bug tracking, and more. The Avaneya project, the people behind it, and the source code as it develops can be found there.

If you are a contributor, make sure you remember to add yourself to the Launchpad project crew.

Launchpad project website:

<https://launchpad.net/avaneya>

Launchpad crew website:

<https://launchpad.net/~avaneya>

10.5.3.1 Bug Tracker

Launchpad's bug tracker tracks all issues submitted to it originating both from users and the crew.

Bug tracker:

<https://bugs.launchpad.net/avaneya>

10.5.3.2 Bazaar Revision Control

We use Bazaar for revision control, hosted on Launchpad. You can browse it on the web here:

³ This explains why top posting is a bad idea: https://secure.wikimedia.org/wikipedia/en/wiki/Top_posting#Top-posting.

<https://code.launchpad.net/~kip/avaneya/trunk>

Some ask why we had not initially chosen a distributed revision control system (DRCS), one class of source control management systems (SCM). SCMs are used to allow multiple people to collaborate over a shared set of files, track revisions and logs, and a number of other things. There are many free programs that allow this, but they can generally be grouped into two categories or paradigms based on how they are expected to be used.

DRCS are akin to peer-to-peer software where they can be used in the absence of a central canonical server. Proponents argue users are better able to work productively when not connected to a network, most operations are much faster since no network is involved, and more. Probably the strongest point raised is it allows participation in projects without requiring permissions from project authorities, and thus arguably better fosters a culture of meritocracy instead of requiring "committer" status. Software that implements these include Mercurial, Git, Bazaar, Monotone, Darcs, and others. This approach has been popularized by the open source movement in recent years, as it captures the "bazaar" approach to software development (think of the Persian marketplace).

CRCS, centralized revision control systems, are akin to peer-to-server model. They have a single canonical repository on a single server. Proponents argue it is more straightforward to contribute to, work is better coordinated, has a more approachable learning curve, backups are more straightforward, and has been around longer. CVS, Subversion, and many others implement this approach. This approach has been popularized by the free software movement, as it captures the "cathedral" approach to software development (think of a central coordinator).

Many people had suggested we use Bazaar because it has a feature that Subversion, what many are use to, does not, DRCS. It is clear that it is perfectly capable of the distributed approach, but that should not be characterized as a feature any more than the specific colour of a car is a feature. It is not a feature, but a preference. Nevertheless, we ended up settling with Bazaar because it can function in the DRCS approach, is the only SCM supported by Launchpad, integrates well with modern graphical GNU desktop environments,⁴ and improves on the features Subversion supports. Besides, it was time to try something new and learning something new is usually not a bad idea.

10.5.3.3 Blueprints

Launchpad provides a feature called Blueprints which allows you to track the design process from basic feature specifications all the way to implementation. Our project's currently available blueprints include:

- **ares-architectural-design:** This document describes the AresEngine's internal architectural design. See the README for details.

<https://blueprints.launchpad.net/avaneya/+spec/ares-architectural-design>

- **ares-package-design:** The AresPackage manifest file format and documentation is provided. See [Section 8.1 \[AresPackages\]](#), [page 15](#) for details.

⁴ As an example, check to see if your distribution carries the *nautilus-bzr* package.

<https://blueprints.launchpad.net/avaneya/+spec/ares-package-design>

- **ares-events-design:** The event type schema and definitions for built-in event types, Events.xsd and Events.xml respectively. See [Section 9.2.7 \[Events\]](#), page 32 for details.

11 Licensing Rationale

Avaneya is composed of different types of files that fall into general categories. The game is licensed under multiple licenses, with a given license for each category. These categories are for *artwork*, *code*, *documentation*, and *music*.

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- **Music:** This includes all music in Ogg Vorbis, FLAC, Speex, or other formats and associated project files.

These objects are licensed under the terms of their respective artists or publishers. We feel that music does not have to be free, but it is preferred that it be at least shareable. This is the position of Richard Stallman of the Free Software Foundation, along with many artists.

Appendix A Glossary

The following is a collection of terms used in the game world that range from the everyday colloquial to technical terminology. Familiarizing yourself with them will be useful in ensuring the game remains as rich as possible.

Endothermic reaction: A chemical reaction that requires energy to be put into it in order to react. An example would be cooking an egg. The egg doesn't change unless you apply heat to it. This is contrasted with an *exothermic reaction*.

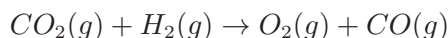
Exothermic reaction: A chemical reaction that releases energy as part of its reaction. An example would be burning wood. As the wood changes, it releases energy in the form of mostly heat.

Genuine Progress Indicator: The GPI is a system of true cost accounting which is intended to be a replacement to the GDP, gross domestic product, sometimes called the gross national product, GNP. The GPI works by taking into account all costs of an activity to society and provides a net balance sheet. The latter, on the other hand, only functions as an income sheet by tabulating the total amount of goods and services produced in a year.

An example where the difference between the two is well illustrated is with the tobacco industry. The GDP would account for the value of all cigarettes sold (a positive figure). Conversely, the GPI would also account for the total value of all units sold, but then go on to subtract the deficits socialized to everyone in the form of health costs, fires, garbage collection, environmental toxicity, and the deaths of approximately 5,000,000¹ people every year (a negative figure).

Regolith: What most refer to as dirt. More technically, it is the the loose heterogeneous mixture of material that blankets the solid rock.

RWGS reactor: The reverse-water-gas-shift reactor is a method of producing oxygen (O_2) from carbon dioxide (CO_2). This is useful because the latter is plentiful in the Martian atmosphere at 95 %.



The process has been known since the mid 1800s and works by reacting carbon dioxide and hydrogen gasses together over a copper-on-alumina catalyst. Aqua (liquid water) and carbon monoxide gas are produced as byproducts. The aqua is split via electrolysis to produce hydrogen and oxygen gasses. The hydrogen can then be recycled back into the reactor and the carbon monoxide purged out into the atmosphere.

The reactor needs to be at 400 °C and at low pressure. It requires about 180 watts of power, or about 3 m^2 of solar panels on a fully sunny day's average solar flux. At that

¹ *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*, Naomi Oreskes, Bloomsbury Press, 2010

energy rate, you can expect to produce about 1 kg per day of oxygen, which is sufficient for a single person. The reactor requires power because it is an *endothermic reaction*. However, it is possible to use a *Sebatier reactor* in tandem, which is an exothermic process, to provide the heat required to drive the RWGS reaction.

To start the process, only a small amount of water is required which acts as a reagent. By importing hydrogen from Earth, it acts to the colonists' advantage in allowing it to be leveraged in the creation of water, or hydrogen gas if needed.

Sebatier reactor: A chemical process for creating methane CH_4 from CO_2 and hydrogen. This is useful because carbon dioxide gas is plentiful in the Martian atmosphere at 95 %.



The reactor needs to be at 400°C and at low pressure. This makes it almost the same as the *RWGS reactor* except that it uses a different catalyst to make methane instead of carbon monoxide. You can either use nickel, which is cheap, or ruthenium-on-alumina, which is safer, but more expensive.

Appendix B Licenses

B.1 GNU General Public License

Version 3, 29 June 2007

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