

Avaneya Crew Handbook

A comprehensive guide for all of our bold contributors.

The Avaneya Crew

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1 Purpose of Handbook

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 classifications that form a subset of it are a hybrid mix of 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 use the platform's native distribution's package manager at all.

The best way to get an idea of the intended audience is to quickly see [Chapter 3 \[Relevant Readings\]](#), [page 4](#) and to ask yourself the type of audience that those resources would probably appeal to.

2.4 Who Is It Not For?

This game will challenge you to think, and maybe even offend you. It is not like other games, and thus it is not for all people. Those who have an attention span of only a few seconds or that believe things originate in cans 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.

We could take a rough guess though by taking the rough inversion of the aforementioned and guess that at least any one of them might be a disqualifier for someone that enjoys the game. These might include:

- *indifference or unawareness of the need to protect their freedom, including software freedom*
- *indifference or unawareness to a sense of community*
- *no particular preference for the science fiction genre*
- *tends to see things disparately rather than as interconnected*

3 Relevant Readings

You should 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 you have, the greater the potential quality of your contributions can be. This is applicable to any kind of complex simulation, and not just Avaneya.

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 Everyone

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

- *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 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.
- *Blender Studio Projects: Digital Movie-Making*
Tony Mullen & Claudio Andaur, Sybex, ISBN 9780470543139, 2010.

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.

- *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 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 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*.

- **Artwork:** This includes all literary works, cinematics, models, audio and voice effects, textures, materials, concept art, fonts, screenshots, and other relevant non-executable creative data.

These objects are licensed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike (BY-NC-SA) 3.0 Unported license, copyright © 2010, 2011 Kshatra Corp. See [Section B.3 \[License CC-BY-NC-SA\]](#), [page 42](#) for the full text of the license.

The license ensures that, under the default conditions, unless given permission, others cannot use it for commercial purposes (NC), must give attribution (BY), and if they alter, transform, or build upon it, they must distribute the resulting work only under the same or similar license to this one (SA). Everyone is free to copy, distribute, and transmit the work, as well as to adapt the work as they like. These are just the default conditions and can be waived with the permission of the copyright holder.

- **Code:** This includes the AresEngine, shaders, Lua scripts, build environment scripts, and any other relevant executable data.

These objects are licensed under the terms of the GNU General Public License 3.0, copyright © 2010, 2011 Kshatra Corp. See [Section B.1 \[License GPL\]](#), [page 24](#) for the full text of the license.

In a nutshell, this license ensures that users have four fundamental freedoms that are always protected. These are the freedom to use the software for any purpose, the freedom to change the software to suit your needs, the freedom to share the software with your friends and neighbors, and the freedom to share the changes you make. The license for most software and other practical works are designed to take away your freedom to share and change the works. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change all versions of a program - to make sure it remains free software for all its users.

- **Documentation:** This includes UML schematics and other design documents, doxygen output, man and info pages, this handbook, and other relevant data.

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The Free Software Foundation explains the purpose of the license as being to make a manual, textbook, or other functional and useful document "free" in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or noncommercially. Secondly, this license preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

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.

5 The Story

5.1 Background

5.2 Storyboard

5.2.1 Opening Cinematic

6 Story Timeline

7 Features

8 Dependent Technology

9 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.

9.1 The Avaneya

9.2 Buildings

9.3 Characters

9.4 Economics

9.5 Environmental

9.6 Food

9.7 Ground Vehicles and Machinery

9.8 Indoors

9.9 Kit

9.10 Locations

9.11 Politics and Legal

9.12 Population

9.13 Resources

9.14 Time

9.15 Weapons

10 The Project Crew

10.1 Specialties

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 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 squeek 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 seperately 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.

10.2 Avaneya Code of Conduct

Version 1.0

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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.

10.3 Current Members

10.4 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 10.3 \[Code of Conduct\]](#), [page 18](#).

10.4.1 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 [here](#) or browse its archives [here](#).

The second avaneya@lists.avaneya.com is for anyone to discuss anything related to the project. It is open to everyone. You can subscribe to it [here](#) or browse its archives [here](#).

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.

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. For more information, consider reading [this](#).
- 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,¹ 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.
- 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. See [this](#) for an explanation of why it is generally a bad idea.

10.4.2 Internet Relay Chat (IRC)

10.4.3 Launchpad

Make sure you add yourself to the project crew page if you are crew:
<https://launchpad.net/~avaneya>

10.4.3.1 Bug Tracker

10.4.3.2 Revision Control

¹ When batch digest mode is enabled, the server will "batch" together emails into groups and then it to you as a single compilation to cut down on the amount of email you receive.

11 Things To Know If You Are...

11.1 General

11.1.1 Fonts

11.1.2 Colour Scheme

11.1.3 Theme

11.2 2D Artist

11.3 Audio Engineer

11.4 Cinematic Artist

11.5 Engineer

11.5.1 Coding Standards

11.5.2 Ares Engine Architectural Design

11.6 Modeller

11.7 Musician

11.8 Researcher

11.9 Scripter

11.10 System Administrator

11.11 Translator

11.12 Voice Actor

11.13 Web Developer

11.14 Writer

12 Gameplay

Appendix A Glossary

The following is a collection of terms used in the game world that range from the every-day 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*.

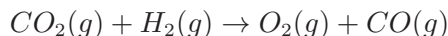
Exothermic reaction: A chemical reaction that releases energy as part of its reaction. An example would be burning wood. As the wood changes, it releases energy in the form of mostly heat.

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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