

Terraformer



Tutorial

version 0.4 beta

Terraformer Tutorial

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Introduction to Terraformer

Terraformer is a terraforming simulator. The program allows you to explore and experiment with a stellar system: its stars, planets, moons, asteroids and comets. It could be our own solar system, or an extrasolar planetary system.

Terraformer gives you the ability to make changes to a stellar system, to measure the results: to experiment. You can warm Mars, cool Venus, crash comets into Saturn, mine Hydrogen from Jupiter, or seed Ceres with life. The choice is yours!

What makes Terraformer unique is its scientific accuracy. The program uses established scientific equations, detailed chemical data and known biological parameters to produce precise, realistic results. The atmospheric chemistry simulator is particularly impressive, reinforcing how fragile our own biosphere really is.

Getting started

Starting Terraformer is easy.

- Double-click the Terraformer program.

A starry night sky will appear with an Information window (Fig 1) in the centre.

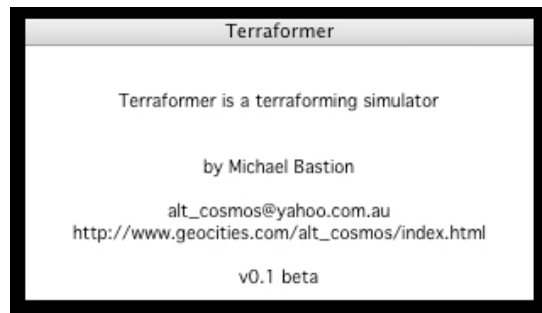


Fig 1. Information window

- Click the Information Window, or wait 5 seconds, to proceed. The Information Window will close and the Stellar window (Fig 2) will appear.

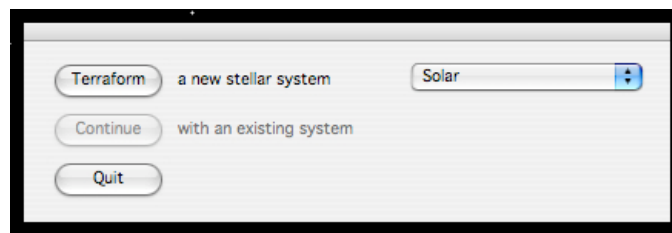


Fig 2. Stellar window

You have three choices.

- Choose a stellar system to terraform, then click the *Terraform* button
- Click the *Continue* button to select a saved stellar file and continue with a previously saved system.
- *Quit* the program, and return to the Finder.

Choosing either of the first two options will take you to the Terraforming Control Station (Fig 3) window. When the Terraforming Control Station window opens you are ready to start terraforming!

Note. In the Beta and Trial versions: The Continue button is disabled and the Solar system is the only system available to terraform.

Terraforming Control Station

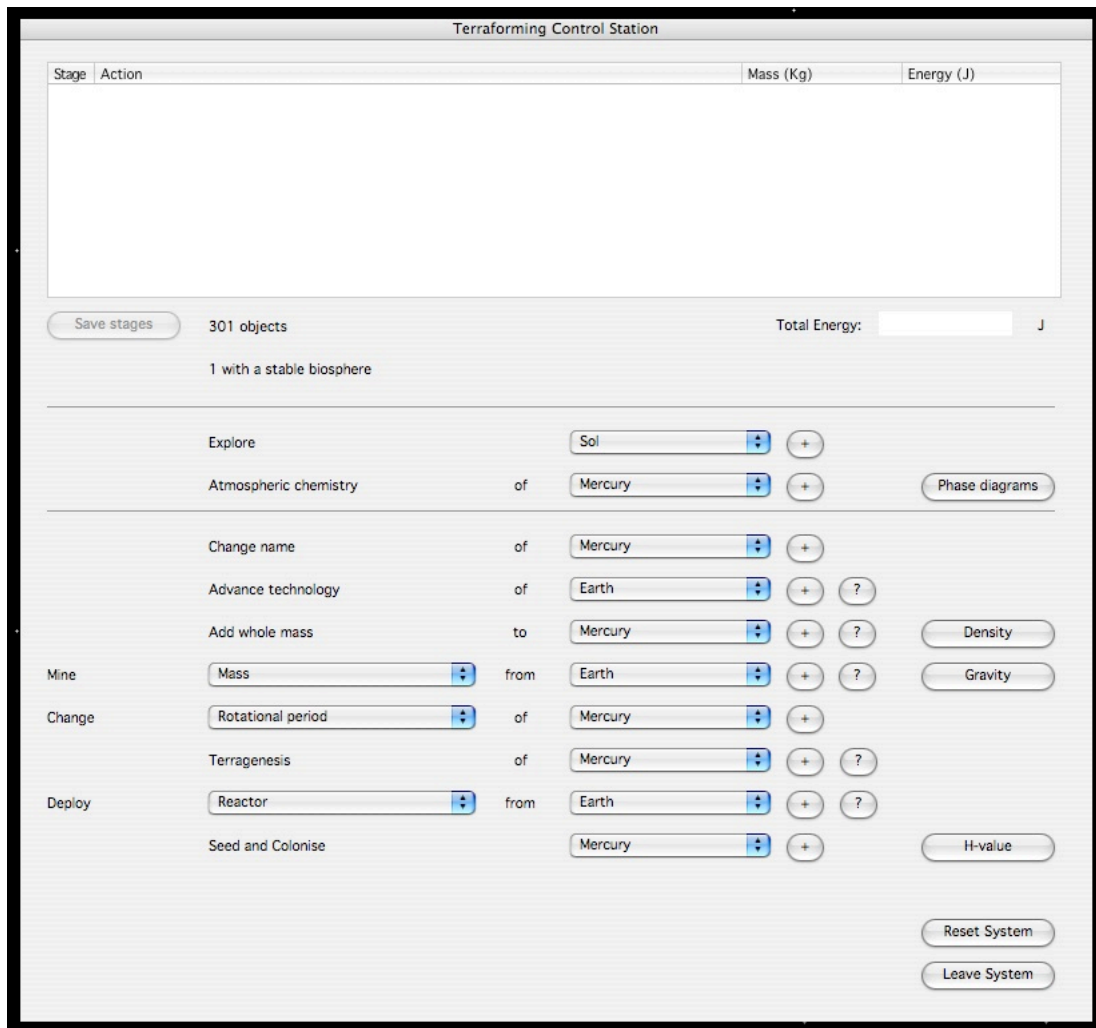


Fig 3. Terraforming Control Station window

The Terraforming Control Station window is divided into three sections - upper, middle and lower. The upper section is the Stage section and includes the Stage list. The Stage list lists each terraforming stage, the action taken, the amount of mass (in Kilograms) involved, and the minimum amount of energy (in Joules) required. The minimum amount of energy required for all terraforming stages combined, can be found below the stage list, on the right-hand side. Below the stage list on the left-hand side is the Save stages button. This button allows you to save all of the stages to a text file, that you can later use. Note: this button does not save the stages to continue later. Next to the Save stages button is displayed the number of individual objects recognised within the system, and below that, the number of objects with a stable biosphere - planets with life.

The middle section is the Exploration section. In this section you will find the *Explore*, *Planetary Chemistry* and *Phase diagrams* buttons.

The *Explore* option is used by selecting the object (star, planet moon etc.) from the object menu, then click on the + button to the right of the menu. Depending on your choice, the Star window (Fig 4) or Rock window (Fig 5) will be displayed. Both windows will display the known details of the selected object. When you're finished with this window - click the *close* button in the top left-hand corner.

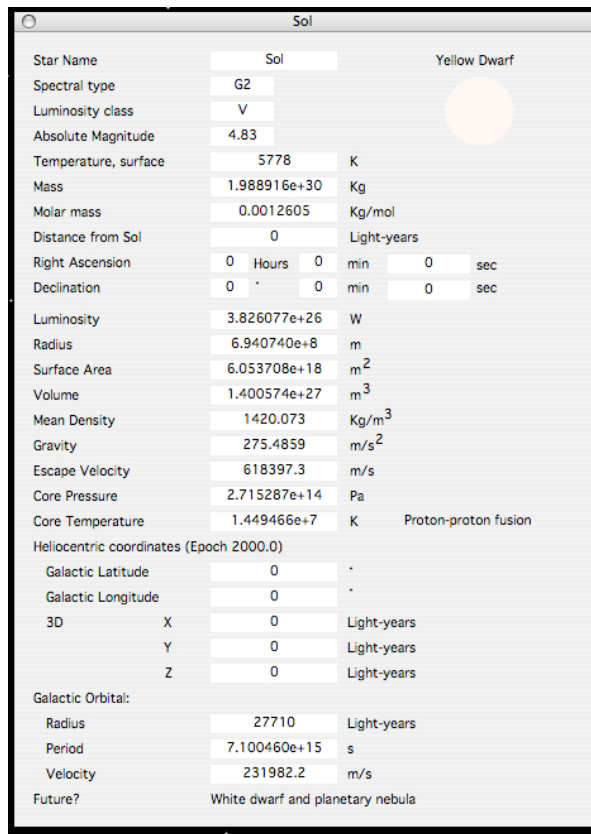


Fig 4. Star window

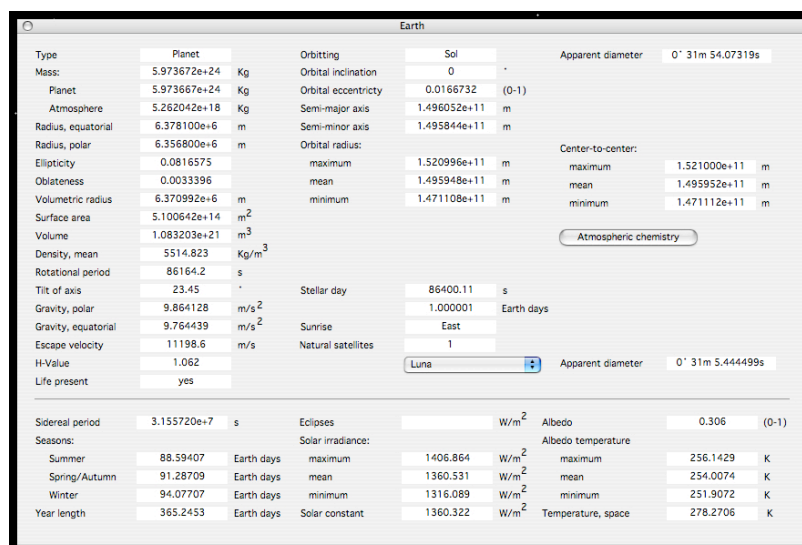


Fig 5. Rock window

The *Planetary chemistry* option is similarly used by selecting the object from the object menu. You should notice there are fewer objects listed in the *Planetary chemistry* menu. This is because fewer objects have stable atmospheres. Only those objects with a stable atmosphere are listed. Click on the + button to the right of the menu to open the Chemistry window (Fig 6). The Chemistry window includes a list of (potential) atmospheric constituents, the mass of each constituent in each phase (solid, liquid, gas), plus the proportion of each gaseous product in the atmosphere. Note: not all constituents need to be listed, only those which are likely undertake a phase change.

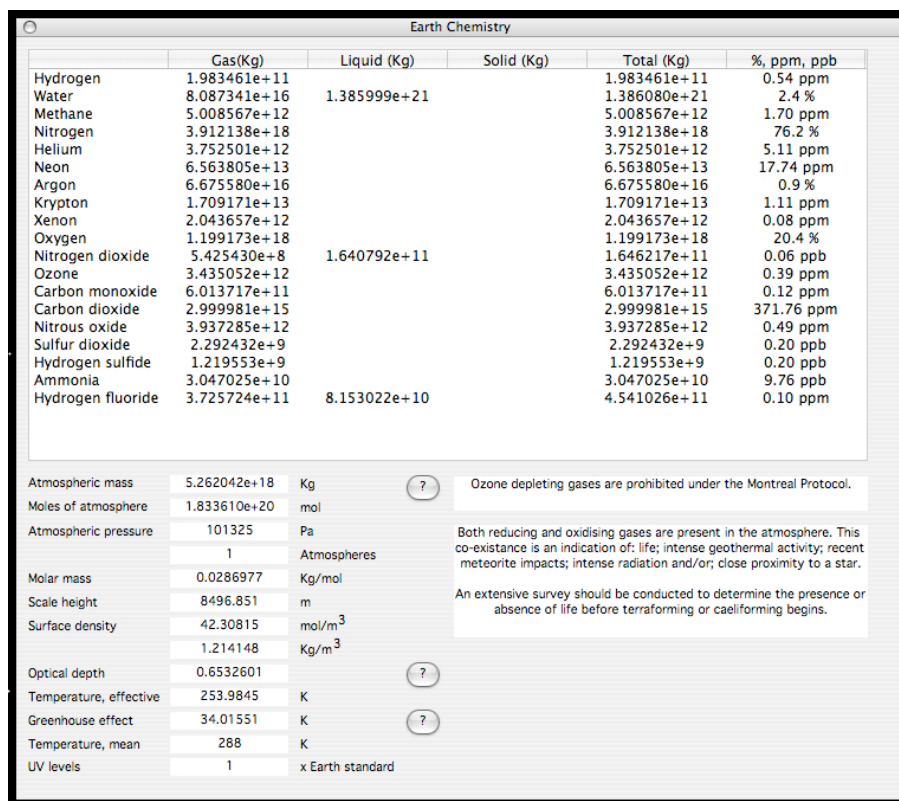


Fig 6. Chemistry window

? (help) buttons provide additional information. When you're finished use the *close* button in the top left-hand corner.

The *Phase diagrams* button will open the Phase diagrams window (Fig 7). This window is a graphical display of the phase diagram for each type of atmospheric constituent. Each phase diagram is constructed from available scientific data, not all phase diagrams are complete, but they are as accurate as possible. The constituents menu lists all constituents tracked by the program, it is not associated with any particular object. The phase diagrams of all constituents can be viewed at any time. Use the + button, in the top left-hand corner, to change between 10 and 100 Bar pressure.

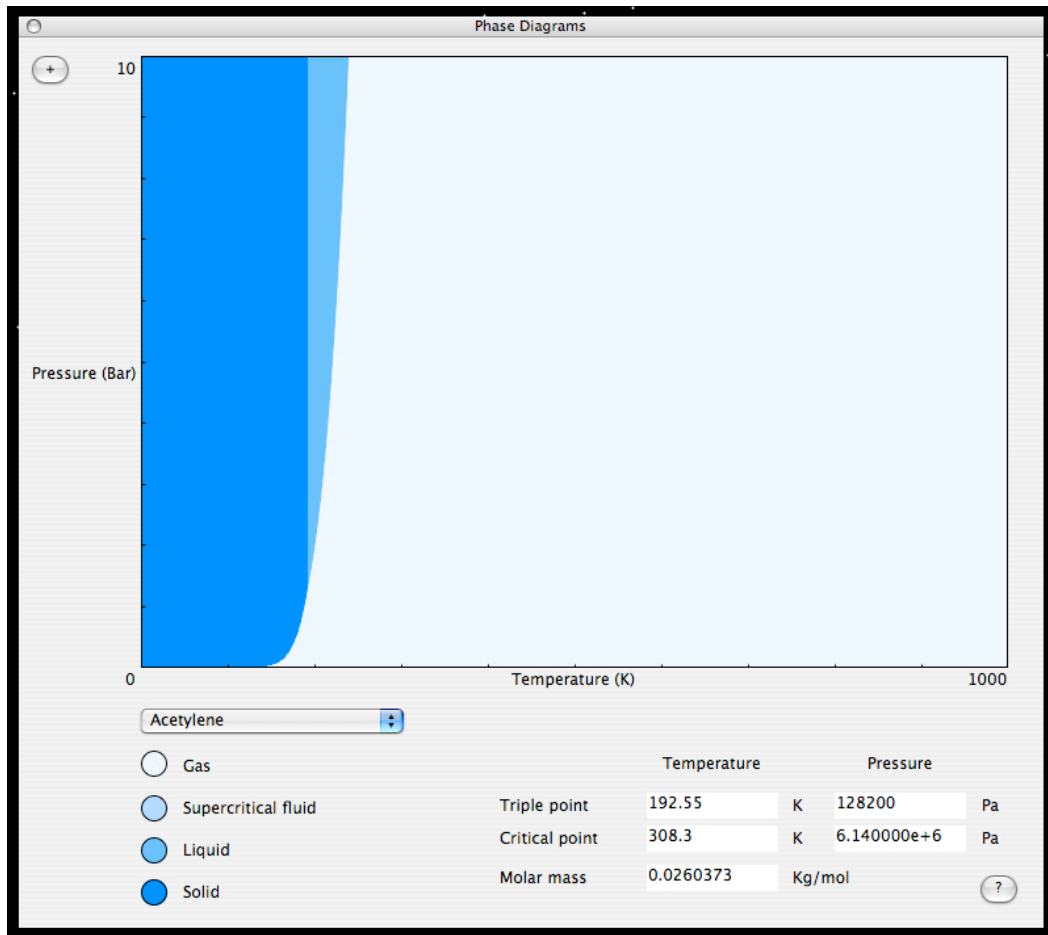


Fig 7. Phase diagrams window

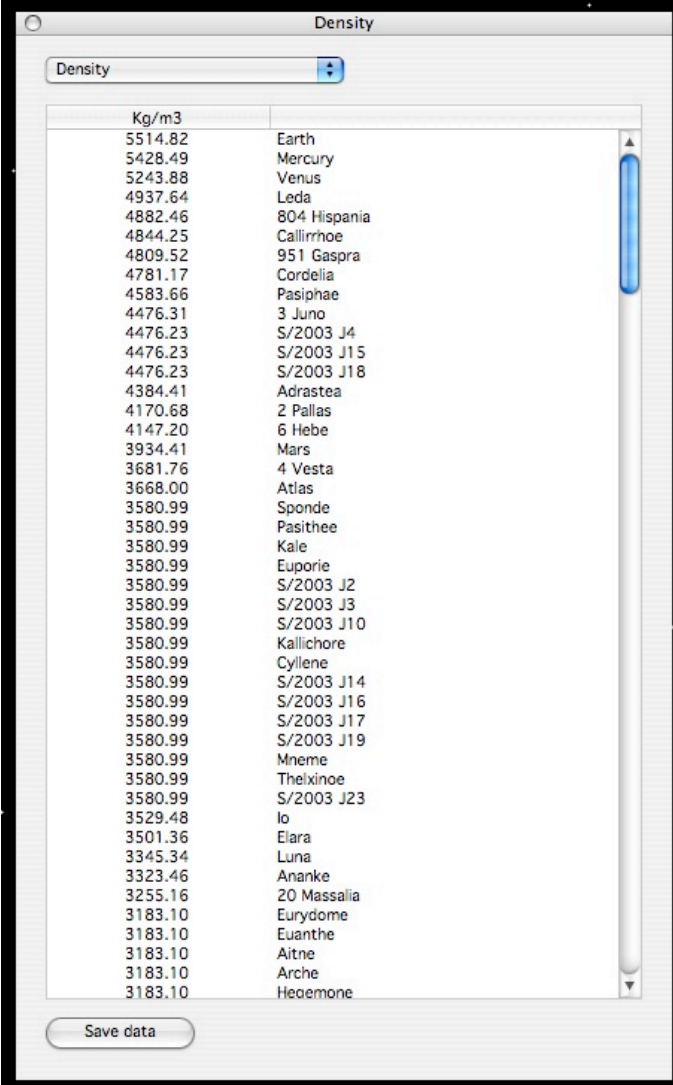
The lower section, of the Terraforming Control Station window, is the Experimentation section. This is the section you will use the most. In this section you will find the *Density*, *Gravity*, *H-value*, *Reset System*, and *Leave System* buttons; a series of ? (help) buttons; and rows of action choices with their corresponding object menus.

The ? (help) buttons provide additional information.

The *Reset System* button will clear all terraforming stages and reset the system to how it was at the start.

The *Leave System* button will close the Terraforming Control Station window and return to the Stellar window (Fig 2).

The *Density*, *Gravity*, and *H-value* buttons will all open the Data window (Fig 8). This window is used to view specific data on all objects in the system in one list. The menu at the top allows you to choose different data sets. When you're finished, use the *close* button in the top left-hand corner.



Density	
Kg/m3	
5514.82	Earth
5428.49	Mercury
5243.88	Venus
4937.64	Leda
4882.46	804 Hispania
4844.25	Callirrhoe
4809.52	951 Gaspra
4781.17	Cordelia
4583.66	Pasiphae
4476.31	3 Juno
4476.23	S/2003 J4
4476.23	S/2003 J15
4476.23	S/2003 J18
4384.41	Adrastea
4170.68	2 Pallas
4147.20	6 Hebe
3934.41	Mars
3681.76	4 Vesta
3668.00	Atlas
3580.99	Sponde
3580.99	Pasithee
3580.99	Kale
3580.99	Euporie
3580.99	S/2003 J2
3580.99	S/2003 J3
3580.99	S/2003 J10
3580.99	Kallichore
3580.99	Cyllene
3580.99	S/2003 J14
3580.99	S/2003 J16
3580.99	S/2003 J17
3580.99	S/2003 J19
3580.99	Mneme
3580.99	Theixinoe
3580.99	S/2003 J23
3529.48	Io
3501.36	Elara
3345.34	Luna
3323.46	Ananke
3255.16	20 Massalia
3183.10	Eurydome
3183.10	Euanthe
3183.10	Aitne
3183.10	Arche
3183.10	Heceomone

Save data

Fig 8. Data window

Performing actions

In the lower section of the Terraforming Control Station window (Fig 3) are rows of actions you can perform. The actions you can perform are:

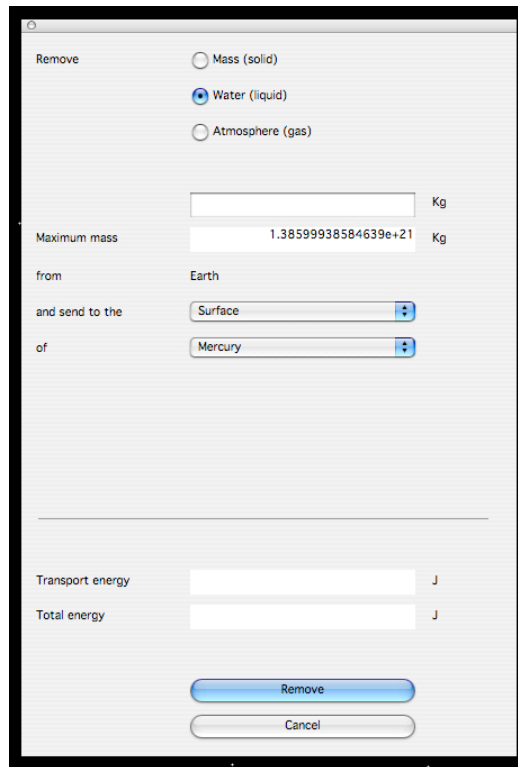
- Change the name of an object
- Advance the technology of a civilisation
- Add whole objects to other objects eg. colliding planets together
- Remove mass from an object and add it to another eg. asteroid mining
- Remove mass from an object to create a new object eg. moon building
- Remove water from an object and add it to another eg. water harvesting
- Remove water from an object to create a new object eg. comet building
- Remove gas from an object and add it to another eg. atmosphere building
- Remove gas from an object to create a new object eg. gas giant splitting
- Change the rotation period of an object eg. change day length
- Change the sidereal period of an objects orbit eg. move it closer to the star
- Change orbital inclination of an objects orbit eg. maximise eclipses
- Change axial tilt of an object eg. alter weather patterns
- Change eccentricity of an objects orbit eg. stabilise seasonal variation
- Move an object to orbit a different parent eg. moon transfers
- Change the albedo of an object eg. thermal atmospheric collapse
- Deploy reactors eg. transport nuclear reactors to a lunar colony
- Deploy robots eg. use robots to build observation stations on Mercury
- Convert atmospheric gases eg. split CO₂ on Venus to release Oxygen
- Compress atmospheric gases and store eg. store methane on Neptune
- Deploy stellar panels and generate energy from stars
- Seed objects with life
- Spontaneously recreate an earth-like planet eg. GOD-mode

Choose the action you wish to perform, select the object, click the + button. A new window will open for you to provide details. Most windows will close automatically when the action is performed, returning you to the Terraforming Control Station window (Fig 3). The action will then be added to the stage list (in the upper section) so you can keep track of the changes you've made to the system.

Note: Stages are not switchable, and you can't undo them if you make a mistake - the same as in the real world. This is deliberate to teach a very important principle of terraforming - Think before you act, whole worlds are at stake. Use the *Reset System* button when you're ready to start again.

Mining

Use the *Mine* action to open the Mining window (Fig 9a & Fig 9b). This window will allow you to mine resources and transfer them to a different location.



The image shows a software window titled "Remove" with a close button in the top-left corner. The window contains the following elements:

- Three radio buttons for resource types: "Mass (solid)", "Water (liquid)" (which is selected), and "Atmosphere (gas)".
- A text input field for "Maximum mass" with a "Kg" unit label to its right. The field contains the value "1.38599938584639e+21".
- A "from" dropdown menu set to "Earth".
- An "and send to the" dropdown menu set to "Surface".
- An "of" dropdown menu set to "Mercury".
- A horizontal separator line.
- Two text input fields for "Transport energy" and "Total energy", both with "J" unit labels to their right.
- Two buttons at the bottom: "Remove" (highlighted in blue) and "Cancel".

Fig 9a. Mine window (Transferring resources)

Remove

Mass (solid)
 Water (liquid)
 Atmosphere (gas)

Maximum mass Kg

from

and send to the

of

Name

Orbital period s

Orbital inclination °

Orbital eccentricity (0-1)

Transport energy J

Total energy J

Fig 9b. Mine window (Creating new object)

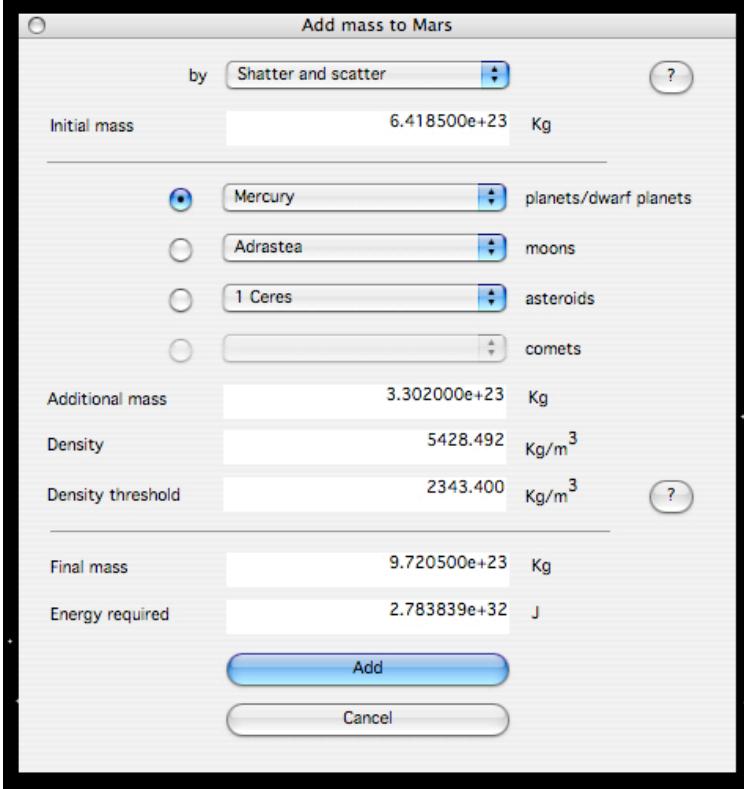
When mining an object you have two choices. You can transfer the mined resources to another object (Fig 9a), or you can create a completely new object (Fig 9b). If you choose to transfer the resource, choose the object you want to add it to. If you choose to create a new object you will need to provide orbital details for the new object: orbital period, orbital inclination and orbital eccentricity.

How do I ...

Terraformer is a simulator. It does what you want it to do. The hardest part is knowing what you want to do, or what you want to try. When you've decided what you'd like to do use the action items to perform them. The following are some examples of what you can do and how...

How do I add Phobos and Deimos together to make one large moon around Mars?

Use the *Add whole mass* action to open the Add window (Fig 10.) and add Phobos to Deimos. You can then rename the moon with the *Change name* action then move it to a different orbit with the *Change* action.



The screenshot shows a dialog box titled "Add mass to Mars". It contains the following fields and options:

- by:** A dropdown menu set to "Shatter and scatter" with a help icon (?) to its right.
- Initial mass:** A text input field containing "6.418500e+23" followed by "Kg".
- Source selection:** A list of celestial bodies with radio buttons and dropdown menus:
 - Mercury (planets/dwarf planets)
 - Adrastea (moons)
 - 1 Ceres (asteroids)
 - (empty dropdown) (comets)
- Additional mass:** A text input field containing "3.302000e+23" followed by "Kg".
- Density:** A text input field containing "5428.492" followed by "Kg/m³".
- Density threshold:** A text input field containing "2343.400" followed by "Kg/m³" and a help icon (?) to its right.
- Final mass:** A text input field containing "9.720500e+23" followed by "Kg".
- Energy required:** A text input field containing "2.783839e+32" followed by "J".
- Buttons:** Two buttons at the bottom: "Add" (highlighted in blue) and "Cancel".

Fig 10. Add window

I've made changes to Mars. How do I know if Mars can now support life?

Use the *Seed and colonise* action to open the Seed window (Fig 11). This window will display an analysis of Mars and its ability to support different types of life.

The screenshot shows a window titled "Evaluation of Earth" with a sub-header "Atmospheric Hydrogen retention". It displays a table of environmental parameters and their suitability for various life forms. The parameters are listed on the left, and the suitability is indicated by green "acceptable" labels for each life form. At the bottom, there are buttons for "Seed", "Colonise", and "Deploy".

Atmospheric Hydrogen retention		Life requires Hydrogen to exist. A planet must hold Hydrogen within it's atmosphere. If not, then Hydrogen will evaporate into space and life on the planet will die.							
H value	1.062	Hydrogen retained							
		Bacteria	Algae	Lichen	Fungi	Plants	Animals	Humans	Robots
Terrestrial surface	Present	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable
Surface gravity	9.864128 m/s ²	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable
Surface water (liquid)	1.385999e+21 Kg	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable
Total atmospheric pressure	101325 Pa	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable
N2 partial pressure	77171.49 Pa	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable
O2 partial pressure	20708.94 Pa	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable
CO2 partial pressure	37.6688 Pa	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable
SO2 partial pressure	0.0000198 Pa	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable
Mean surface temperature	288 K	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable

Fig 11. Seed window (showing Earth)

How do I shorten the length of a Venusian day?

Use the *Change* action to open the Energy window (Fig 12). This window will allow you to change the rotational period of a planet, shortening or lengthening its day.

The screenshot shows a window titled "Change the rotational period of Venus". It contains input fields for "Initial" (2.099700e+7) and "Final" (s), a "Change" button, and a "Cancel" button. Below the input fields, there are radio buttons for "Prograde" (selected) and "Retrograde". To the right of the "Change" button, there are fields for "Minimum" (5189.935) and "Maximum" (n/a). At the bottom, there is a text box with the following text:

Energy required [] J

The length of a planets day is determined by the rotational and orbital periods. The rotational period will effect equatorial gravity and polar flattening (ellipticity). The day length will effect weather patterns, photoperiodism in plants and the circadian rhythms of animals. If the planets day does not match 1 Earth day then introduced plants and animals will be forced to adapt. This evolutionary pressure and planetary isolation will create new species, but the planets ecosystems will take longer to stabilise.

Fig 12. Energy window

I've colonised a new world. How do I accelerate its technological advancement?

Use the *Advance Technology* action to open the Technology window (Fig 13). This window will allow you to advance the technology of an existing civilisation, giving it the ability to launch rockets and build their own reactors.

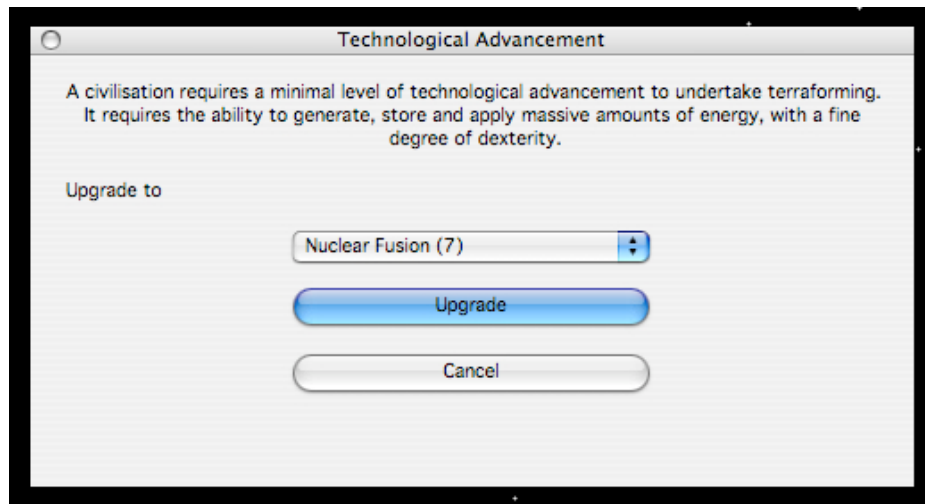


Fig 13. Technology window

Alpha and Beta versions

The beta version is, at first, limited. Additional features will be added as the beta progresses. Additional features will include:

- Extrasolar planetary systems

The alpha version will include all features.