Jonathan Street's Method

written by Jonathan Street on August 10, 2003

Terraforming Mars can, I believe, be broken down into seven key steps and these I outline below:

- Exploration of the planet and the establishment of a permanent, high-bandwidth data connection

- Establish a base on the surface

- A manned mission

- Infrastructure transfer

- Terraforming begins

- Terraforming process

- Mars is terraformed

Seven nice small steps. Okay, I'm joking. These seven steps however do require different approaches and seem, to me at least, to be a logical way in which to tackle this most colossal of goals. Below I will discuss each stage in detail.

Exploration and data link – This is already happening but much more still needs to be done. As more probes are sent to Mars and as they send back progressively more data a permanent, reliable data connection will become more and more vital. It will also be needed in later stages of terraforming.

We know a lot about Mars but there is still so much more we need to know. Some of the data we need to know includes; detailed analyses of where the water on the planet is and in what concentration, the first surveys are in but that is exactly what it is, an initial survey. We need to know what the ground conditions are like, is the ground hard enough to establish a colony on it? Can we drive a 20 tonne excavator across it? We need a far more detailed understanding of the weather conditions, especially the duststorms, but also how much light the surface receives, the particulate levels in the atmosphere and the size of these particles. Even knowing where metal ores are in concentration before continuing at this stage would be useful.

Establish a base on the surface – Before a manned mission will be possible we must know they will be able to survive on the surface and will be able to return. Constructing a base before this happens will make a manned mission cheaper, especially if their food supplies and food can be synthesised on the planet automatically in anticipation of their arrival.

Having an established base has other advantages, it will speed the establishment of infrastructure later on in the terraforming process, a bridgehead fro which to expand.

My plan would be to transport to Mars a base divided into sections or modules. These will then be landed on Mars as close to each other as possible to be retrieved and assembled by robots. The rovers sent to Mars are already highly autonomous allowing for control from Earth to be minimal, which is crucial bearing in mind the time delay inherent in communications between Earth and Mars. In terms of the work that will need to be done there are, or will be, parallels between the deep ocean and Mars. In both environments direct control by humans is difficult and it is vital that robots and unmanned vehicles can perform every task needed to complete a project. We can learn a lot from how these problems are tackled in the deep ocean and must apply the lessons learned. If we forget to include a hammer in our robots toolkits it will be 6 months at least

before one can be sent up to complete the task needed.

A manned mission – In my view this is optional at this stage, it is my view that everything can be remotely operated from Earth. However the publicity that would come from a manned mission to Mars may well be worth the added cost and danger.

There is also one other point to note here, there are ethical concerns over terraforming Mars and in my view terraforming a planet the human race hasn't even visited yet will raise these concerns in many more people. A manned mission may be necessary to justify terraforming.

Infrastructure transfer – The terraforming process will require a lot of infrastructure to be established. I will go into what I believe to be necessary later as right now we need only be concerned with getting the equipment needed to Mars. Whatever can be built on Mars should be. We must minimise the amount of equipment that must be launched from Earth.

The most likely method of transfer will be in three steps. Launch, transfer and landing. Hopefully the X-prize will produce a cheap, reusable craft that can carry the equipment we need into Earth orbit. From there it will be transferred to a specially designed ship for the transfer to Mars. Again this should be reusable so that fewer transporters need to be launched. Also, being specially designed for the interplanetary journey will mean that the most suitable propulsion methods can be employed. The third step involves another reusable craft to carry the equipment down to the planets surface. This will then be launched back into space. As the gravity on Mars is less than on Earth this should be easier than launching multiple landing craft from Earth.

The transfer from Earth to Mars will be the slow step in all likelihood but if the transporter is able to carry several loads of launch vehicle cargo to Mars then this will not be a problem, cargo can be stored in Earth orbit until it can be picked up.

Terraforming begins – Okay, onto the interesting bit. Firstly to understand what we need to do we need to know what we want to do. We want humans to be able to survive on Mars and for this to be possible we need to look at the differences between Mars and Earth, and more specifically, where Mars is lacking. The principal differences are: -

- Air pressure

- Temperature

- Atmospheric composition

- Radiation (No magnetosphere)

- Geologically dead

- Less gravity

The first 3 of these must be changed, without doing so it will be impossible to say that the terraforming process is complete. The last 3 are less vital and in my view we will be able to cope with these.

As the first 3 are the most vital it is here that I will concentrate. If we can increase the temperature then this will cause carbon dioxide at the poles to sublime and thicken the atmosphere. This then should be our first priority. The facilities must be brought from Earth to create PFC's in the atmosphere. These gases are powerful greenhouse gases, trapping the heat of the Sun at the planets surface. This will lead to carbon dioxide being released and a subsequent, further rise in the temperature. This is a positive feedback in that the PFC's only kick-start the warming of the planet.

Terraforming process – Simply warming the planet up though will not be enough. This will thicken up the atmosphere, increase the pressure, but it will be almost all carbon dioxide. We won't be able to go out into an atmosphere such as this. This is just the starting point.

On Earth the atmosphere consists of roughly one-fifth oxygen, although we can survive on less with adequate acclimatization. To convert the carbon dioxide to oxygen we must turn to plants. On Earth plants have been fulfilling this exact task since they came into existence. They can perform the same task on Mars. If, however, you plant a tree sapling onto the plains of Mars the chances of getting a tree are slight, just as it is unlikely you will see a tree growing on the waters edge of a beach. The ecological principle that rule on Earth will not change on Mars.

The Martian surface is effectively rock and sand. There is no organic matter in the soil to support specialized plants such as trees. Before we plant trees we must first drastically alter the soil conditions. Plants can also do this although nothing as grand as a tree. The first biological species to be introduced will be simple; algae, bacteria and fungi.

These will slowly photosynthesize, grow and finally die. The dead organisms will be broken down by other bacteria and will slowly build up the organic content of the soil. They will also increase the availability of nutrients such as nitrate that will be crucial to higher organisms. As the soil condition improves it will be able to support ever larger plants and as these die they will have a far greater effect on the soil, depositing far more organic matter than there more simple and smaller predecessors. Eventually we will see tall trees on the surface of Mars. In ecology this process is known as progression. Small plants giving way to larger plants; until finally, what is known as the climax community is reached. This is the group of plants and animals that is stable in an area and will not change unless the local conditions change.

We can't try to convert the whole surface of Mars in one step but will progression we don't need to. Just as with the carbon dioxide a positive feedback loop will begin to occur. Once we have established several small areas they will begin to spread and eventually they will cover the entire planet.

Nature has a superb way of finding the optimal organism for an environment but nature has time. If we want to terraform Mars quickly then waiting for nature to create the optimal plants will be too slow. We can give nature a helping hand using genetic engineering. This topic has already been discussed in several articles so here I will only summaries the possibilities.

On Earth there are some environments similar to Mars and life is found here, they are often specialised and adapted to these environments. Using genetic engineering we can take these adaptations and put them in other organisms so that they may be able to survive on Mars. This is a very powerful tool and one that can be used to great benefit in our terraforming of Mars as the organisms we release onto Mars will face many challenges. The radiation and the temperature are obvious problems but there are others, for example due to the large percentage of iron oxide on the planets surface the soil is likely to be acidic, not all plants will be able to handle this but genetic engineering will allow us to overcome this.

The best place to begin to plant out Mars will be the very same areas that are annually ravaged by sandstorms. This will present a serious problem in terms of continued progress. Although it will be possible to shepherd life through these difficult times it would be helpful to be able to reduce the severity of these sandstorms. This would have another advantage in terms of the terraforming process. The sandstorms throw up a lot of dust that remains in the atmosphere, blocking out the Suns rays and reducing the temperature at the surface. If we can reduce this then the planet will be heated faster. As the planet warms up and the ice caps are melted the resulting oceans will reduce the range of these sandstorms and provide another area in which life can thrive. Also as the oceans are heated, the rain produced will clean the air of the dust and also suppress the sandstorms by moistening the ground and causing it to stick together more.

Life on Earth started in the oceans and it still today provides a stable, productive environment. Once Mars is

warm enough to allow it, the oceans should be seeded with algae, bacteria and fungi and later larger plants and algae (seaweed) and fish can be introduced. Another advantage of the oceans will be to act to prevent a runaway greenhouse effect by absorbing carbon dioxide.

The sooner we can introduce plants, algae and fungi to Mars the better and this will require some method of protection against the sandstorms and other hazards of the Martian surface. One solution is I believe to encapsulate algae and fungi (algae and fungi are the constituents of lichens which are talked about a lot in the terraforming of Mars). This will give them mechanical protection and keep them together in sufficient density to form via growth. Lichens tend to be very slow growing and anything that can increase their growth is a positive advancement.

Mars is terraformed – So far we will have increased the air pressure, increased the temperature and improved the composition of the atmosphere. We have not, however, even attempted to block out harmful radiation from the Sun, restarted geological activity or increased the gravity of Mars. Thickening the atmosphere will serve to reduce the level of harmful radiation reaching the surface but this may not be sufficient. It has been suggested that it may be possible to create an artificial magnetosphere and so shield the planet in this way and this would seem to be the best solution. Until this can be established however there is some measures we can take to reduce the dose people will receive on the planets surface. Radiation will be at the worst when Mars is directly in the path of bursts of solar radiation from the Sun. A satellite positioned between the Sun and Mars will be able to provide an early warning of any incoming burst. Such a satellite already exists between the Earth and the Sun so this would require no new technology, only its application in the defence of another planet. This early warning will give people enough time to enter special rooms in colonies specially designed to offer improved radiation protection. These may be buried underground or involve extra shielding.

This leaves us with two problems for which I believe there is little we can do. To increase the gravity of Mars would require one of two approaches. Using some technology not yet created is one possibility but this is unlikely simply due to the fact that it relies on unknown technology that is not even on the development board yet. The other possibility would be to crash the two Moons of Mars and as many asteroids as possible into the planets surface. This would likely destroy the surface of the planet and increase its mass. Eventually the surface will cool down sufficiently for terraforming to begin again but this approach will mean the planet is out of bounds for centuries to come. I don’t think this is a viable option.

As we can’t change the gravity of Mars then we will need to adapt to the gravity of Mars. Exercise will reduce muscle wastage and load-bearing exercises should help to prevent bone wastage. This is a problem we can overcome and the Mars Society space based artificial gravity simulation will help to provide some answers.

This just leaves the problem of no geological activity on Mars. On Earth, the surface of the planet is continually, if slowly, replaced providing fresh new ground. This doesn’t happen on Mars and as we terraform the planet erosion will eventually lead to a featureless land. This will take many millennia but will eventually happen. In theory, the oceans created by terraforming Mars will eventually silt up. This is a long-term problem and can easily be dealt with by occasional dredging. Even if left untended the problem would not manifest itself for tens of thousands of years, but should still be considered

As with the gravity of Mars, restarting the geological activity of the planet will be incredibly difficult and slow down the terraforming of Mars by an unacceptable degree.

When terraforming is complete the surface of Mars will have been transformed. Gone will be the dusty red plains and in their place will be forests and grasslands cloaking the planet. The oceans will be teeming with life and the planet will be able to support many communities while still being empty enough to provide a challenge to anyone willing to take it. The economy of Mars will largely be self-sufficient although there will still be regular shuttles making the journey between Earth and Mars. It will be commonplace on Earth to meet people with relatives on Mars.

Where we go next will be the only question still unanswered.

This is but the briefest of outlines of a method to terraform Mars. It still requires much work and many blanks need to be filled in. As more information comes from Mars and as my own knowledge improves I will continue to update this method until it is a fully detailed summary of the exact path to success. The terraforming of Mars.

Works Cited:

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