HOPS SPACE APPS SOLUTION

H.O.P.S. stands for Hydrogen Oxygen Propulsion System. It is a portable four-thruster jet pack​ that can be used to efficiently and safely navigate Mars. Thrust will be produced by the combustion of hydrogen in oxygen, stored in pressurized Kevlar tanks, one in the back and one in the front. The hydrogen tank is twice the size of the oxygen tank as hydrogen and oxygen react in a 2 to 1 ratio. The pilot will have a belt attached to him, which will be supported by crotch and shoulder straps. It will connect to an outer ring using springs of high young modulus. The thruster arms will be attached to this outer ring. A gyroscopic version of H.O.P.S. (G.H.O.P.S.) can also be used. (G.H.O.P.S. is explained later)

Producing Fuel at Home base:

Oxygen can be produced by the decomposition of CO2 (Mars' atmosphere is made up of 96% CO2). Water can be produced by the 'Sabatier reaction': CO2 +4H2 ==> 2H2O + CH4    -165 kJ/mol, this also takes advantage of the Martian atmosphere. The methane produced can be used as an everyday fuel at base camp. Microbial electrolysis can be used to split the urea in urine into hydrogen and oxygen.

Producing Fuel on the Go:

Water ice can be harvested, and by using a device (container with a lens) that magnifies the sunlight on mars (of intensity 590 W/m^2), can be concentrated onto a single focal point within a concave container. The ice will lie on this focal point. The container, depending on where you are on Mars, must be pressurized so that the ice does not sublimate. When the ice melts the resulting water can be used to produce hydrogen and oxygen using electrolysis. Simple and light (pressurized) apparatus can be used to carry out the electrolysis. Microbial electrolysis can also be used in an emergency situation.

Locating Fuel on the Go:

There are five satellites currently orbiting Mars. 3 to 4 of these are needed for a GPS system with an accuracy of a meter. Satellite imagery, a GPS location system (including a GPS tracker embedded in the helmet) and a spectrometer (also embedded in the helmet) can be used to detect and locate water ice.

Charging:

The battery that powers the electrics of H.O.P.S. can be charged while the H.O.P.S. is in use. A piezoelectric material will coat the pilot's gloves. The pilot can produce current by rubbing his gloves together or moving his hands. This electricity will be fed to the battery. A carbon nanotube spring can be used in the bionic boots. A stationary magnet within the spring will mean that whenever the spring is compressed and relaxed there will be a current produced in the spring (due to electromagnetic induction) that will charge the battery (carbon nanotubes are very good conductors and also have a release energy to elastic potential energy ratio that is 2500 times that of a hardened steel spring). The same device that is used to melt water ice can be used sublimate dry ice (which normally covers the water ice on Mars). Thankfully, the sublimation point of dry ice on Mars is quite close to its natural temperature. This means that not that much energy is required to produce the gaseous CO2. Two tubes that are at a lower pressure than the main concave container can be attached to the main container. The CO2 (produced by the sublimation process ) will move through these tubes, spinning small turbines that will generate current. This current can also be used to charge the battery.

Navigation and Steering:

Steering will be achieved through thrust vectoring. Thrust vectoring is something even helicopters do nowadays to retain stability and maneuverability. Each thruster will be able to move about its own axis as it will be placed within two servos which allow movement in two planes. A fuel distribution system that makes use of valves will be used to determine the thrust each thruster exerts. This system is also shared by planes on Earth. Movement will be controlled by a joystick. For extra stability and reliability the thruster-arms are attached to the belt previously mentioned.

So if you’re an astronaut: Pushing the joystick forward takes you forward, pushing it left takes you left, right takes you right and pulling it backwards takes you backwards. Simple.

Since there is hardly any atmosphere on Mars, the stars can be seen and used as reference points for navigation. Moreover, Mars has weak magnetic field so other options such as a compass are not available. During the day, instead of using the stars you can navigate using the position of the sun. Using a solar filter you can also distinguish the stars even during the day.

Another option would be to use a series of beacons (that work in all weather conditions on Mars) to map out the area the network covers. Due to the minimal atmosphere of Mars, the beacon’s coverage will be much greater to what it would be on Earth.

G.H.O.P.S.

The Gyroscopic H.O.P.S. consists of two main components: a spherical wire outer frame and an inner pole with a differently-weighted concave plate at each end. These two parts rotate about each other. The bottom plate will be heavier than the top one. The thrusters will apply a force with a large horizontal component so that the center of gravity is displaced from its lowest position. In other words, the heavier plate will rotate to where it is behind the astronaut. The ball will now roll forward due to the thrust exerted and due to the moment produced by the return of the heavier plate to its starting position. When H.O.P.S. is rolling, the astronaut will be rocking back and forth in his seat. If the thrusters exert thrust with a great enough vertical component, H.O.P.S. will lift off the ground and will be able to fly as normal.

Safety:

To avoid any burning hazards to the astronaut, the thruster will have a safety mechanism that will only allow it to be at a certain minimum angle away from the pilot. If there is a failure in the electronics and the thrusters go out of control, the thrusters will not be able to move too close the pilot and potentially harm him.

The oxygen and hydrogen will only come in contact with each other in the thruster as they will travel through separate pipes. This means that combustion only occurs in the thruster and not in other parts of the soot.

Mobility:

While in flight, the position of the arm of each thruster is fixed. However, when on foot, the astronaut can fold up these arms, unlock their position on the belt and move them to the back of the belt for better mobility. The thrusters, due to the material they're composed of (carbon fiber), will be lightweight. The astronaut will also be able to easily move around due to the flexibility the bionic boots provide. A flexibility that is shared by nature, as ostriches use the same “technology”(called Achilles tendon of an ostrich) in their feet to move around, reaching speeds as high as 45 miles per hour, on Earth.

Materials:

Carbon Fiber: used for the thrusters, thruster-arms and bionic boots (Melting temp. of 3500 degrees Celsius- on Earth. Temperature of the combustion of hydrogen in each thruster is around 2300 degrees Celsius- on Mars)

Kevlar: Used for compressed gas fuel tanks and for insulation of the thrusters.

Quartz: Piezoelectric material that coats part of the gloves.

Cooling

The hydrogen will be pumped in just before the oxygen. It will cool the thruster down and then it will burn in oxygen to produce thrust. Dry ice could also be used to cool the engine. CO2, or Martian 'air', could be pumped through the thruster to cool it down.

Why not Other Fuels

The combustion of hydrogen is an incredibly efficient reaction. It also produces a large amount of energy -572 kJ/mol. We initially thought of reacting CO2 with Mg however this produces solid byproducts like soot that coat the engine, preventing it from functioning. In addition, the problem with using plasma is that an incredible amount of energy is needed to be produced. It would also be an extremely dangerous propellant due to its high temperature (some thousands degrees Celsius). Moreover, the problem with using ion propulsion is that it would take far too long to accelerate the pilot to a decent speed. It also does not allow for sharp maneuverability.