INVESTIGATION OF THE REVERSE WATER GAS SHIFT REACTION FOR PRODUCTION OF OXYGEN FROM MARS ATMOSPHERIC CARBON DIOXIDE. Tom Meyer[1] and Robert Zubrin[2], [1]Boulder Center for Science and Policy, P.O. Box 4877, Boulder Colorado 80306, (303) 494-8144, -8446 FAX meyertr@colorado.edu, [2]Pioneer Astronautics, 445 Union Blvd., Suite 125, Lakewood CO 80228, USA.

This presentation will report on progress of the first phase of the project titled Mars In-situ Resource Utilization Research (MIRUR) being performed under a NASA ACRP grant, Robert Zubrin, PI and Tom Meyer co-investigator. The MIRUR proposal is a plan to undertake a study of Mars in-situ resource utilization strategy and applications centered upon exploiting the unique potential of the reverse water gas shift (RWGS) reaction as a means of producing oxygen, water, storable fuel, and other hydrocarbon materials on the surface of Mars out of Mars atmospheric carbon dioxide and other readily available indigenous materials.

The first phase of the research includes a comprehensive analytical study examining the potential applications for engineering subsystems and mission strategies made possible by such RWGS based subsystems, and will include an actual experimental demonstration and performance characterization of a full-scale brassboard RWGS working unit. By the time of this presentation the laboratory demonstation unit will not yet be operational but we will present the results of our analytical studies to date and plans for the ongoing work.

The reverse water gas shift (RWGS) reaction has been known to chemistry since the mid 1800's. While it has been discussed as a potential technique for Mars life support and propellant manufacture in the literature, there has been no experimental work done to demonstrate its viability for such applications to-date. The RWGS reaction is given by equation,

$$CO_2 + H_2 \Leftrightarrow CO + H_2O \qquad \Delta H = +41.3 \text{ kJ/mole}$$

This reaction is mildly endothermic and will occur rapidly in the presence of an iron-chrome catalyst at temperatures of 400°C or greater. Unfortunately at 400°C the equilibrium constant Kp driving it to the right is only about 0.1, and even at much higher temperatures Kp remains of order unity. Thus there is a significant problem in driving the RWGS reaction to completion.

However, assuming that reaction can be driven as written, an oxygen production system can be created by coupling the above reaction with a water electrolysis reaction. That is, the CO produced by the above reaction is discarded while the water is electrolyzed to produce oxygen (the net product), and the hydrogen can be recycled to reduce more carbon dioxide. Barring leakage losses, if all of the hydrogen is recycled, this process can go on indefinitely. The only reagent needed is a small amount of water which may be imported or obtained from indegenous sources.

Since the RWGS reaction is mildly endothermic and does not go to completion, ways must be found to shift it further toward the right, that is further toward completion. There are a number of ways that this could be accomplished. These are:

a) Overload the reactor with CO_2 to force the complete consumption of H_2, and then recycle the excess CO_2 in the exhaust stream back into the reactor.

b) Overload the reactor with H_2 to force the complete consumption of the CO_2, and then recycle the excess H_2 in the exhaust stream back into the reactor.

c) Operate a system that removes water vapor from the reactor, thereby driving the reaction to the right. Such a system could either be a desiccant bed or condensing apparatus.

d) A combination of approaches (a) and (c).

e) A combination of approaches (b) and (c).

This presentation will discuss the anticipated results from applying these strategies including estimates of the yields and energy costs and review the practical problems. We will also review the overall goals of the project, compare the advantages and disadvantages of other systems for the production for oxygen, and discuss the possible mission strategies made possible by RWGS.