EIR Science & Technology

To Mars with nuclear power, not 'comic book physics'

An interview with Dr. Steven D. Howe of Los Alamos National Laboratory, who refutes the claims of Bob Zubrin's trendy "Mars Direct" program, and shows what is required for a serious Mars mission.

Dr. Howe is Program Development Coordinator in the Applied Theoretical and Computational Physics Division of the Los Alamos National Laboratory. From 1990-94, Dr. Howe was the laboratory's coordinator for Space Nuclear Propulsion Technologies, and before that, managed Los Alamos's work on the National Aerospace Plane. During his 15 years at Los Alamos, Dr. Howe has investigated potential laboratory programs and technologies involving space radiation modeling, antimatter physics, Mars mission requirements, and advanced propulsion. He received his Ph.D. in nuclear engineering in experimental particle physics in 1980, after which he spent a year as a visiting scientist at the Nuclear Research Center in Karlsruhe, Germany.

Dr. Howe was interviewed by Marsha Freeman on Jan. 23, 1997.

EIR: Over the past eight months, there has been increased interest in human missions to Mars. One of the proposals that has been put forward, and attracted a lot of publicity, is Bob Zubrin's proposal, called "Mars Direct." This is based on the idea that the only way the United States will have a manned Mars program, is if it can be done quickly and cheaply. He has outlined a program that he thinks can be accomplished in ten years, for about $20 billion.

In order to sell the idea that this could be done in ten years, Zubrin proposes using conventional chemical rocket technology. To do that, he has to try to convince you that you don't have to develop more advanced propulsion in order to get to Mars any faster than 6-8 months each way, because there is no big risk to the crew, in terms of exposure to interplanetary radiation.

However, the Task Group on the Biological Effects of Space Radiation of the Space Studies Board of the National Research Council released a report last December, titled "Radiation Hazards to Crews of Interplanetary Missions: Biological Issues and Research Strategies." They say that "more than a decade of research is needed to answer even the narrowest set of key questions. . . ." They make the point that you have to reduce the areas of uncertainty and that research "must be completed prior to undertaking the detailed design of a vehicle carrying a crew into space for periods of extended exposure."

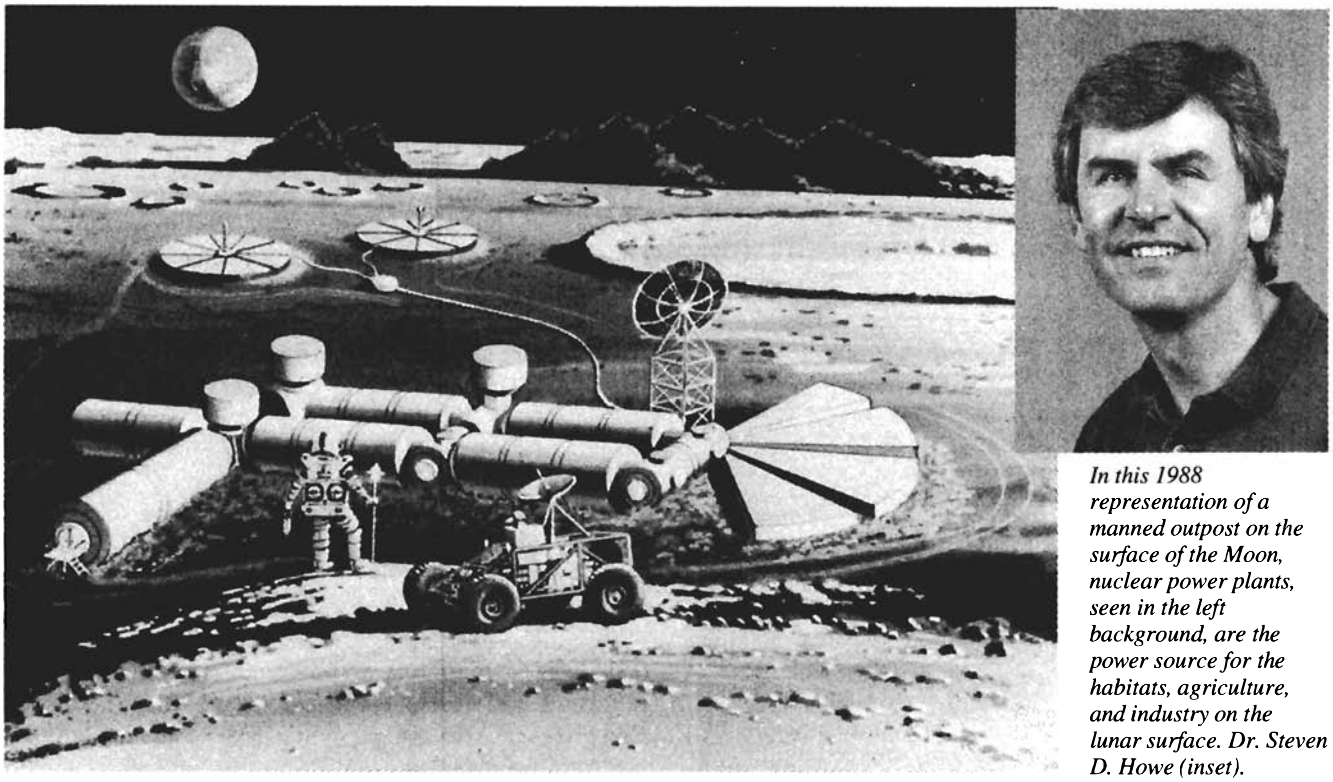
Have you looked into this question?

Howe: Yes, absolutely. I think Bob Zubrin is totally wrong. He's absolutely wrong. I would make one caveat to that study. What they are saying is that the effects on the body of very highly ionized nuclei, like an iron nucleus, at very energetic speeds, are unknown. The uncertainties they are talking about are from the very heavy element composition in galactic cosmic rays.

The proton constituent, which is 95% of galactic rays, but only about half of the dose a human might get, is well known and understood. If you can shield your ship to remove the heavy nuclei, then the uncertainty they are worried about should not exist.

If you were to put that kind of shielding on a ship, however, the ship [would be] so heavy, that a chemical propulsion system can't even begin to handle it as far as a Mars mission. But a nuclear system can easily handle that [additional] mass.

EIR: The other point they make, is that we also do not know the spallation effect of various shielding materials. They use the example of lead, saying that on the ground, lead is fine, because if you are producing secondary particles in the shielding from the radiation, no one is in close proximity. But there are secondary particles produced using some shielding materials, like lead, that lead to effects that are more harmful than



In this 1988 representation of a manned outpost on the surface of the Moon, nuclear power plants, seen in the left background, are the power source for the habitats, agriculture, and industry on the lunar surface. Dr. Steven D. Howe (inset).

those produced by the original radiation you were shielding against. And, in space, astronauts will be in close proximity.

Howe: There, I think, they are talking specifically about very high-energy neutrons, because we clearly know what secondary particles are produced. We have an accelerator here, for example, at Los Alamos, where the energy of the proton beam is right at the peak of the galactic cosmic ray spectrum. Other accelerators around the world are even higher-energy, so we can measure directly the secondary particles. The question is, what is the physiological response to the particles? And that is unknown. Nobody has done that work.

But you can circumvent that problem by shielding with low-Z [atomic number] material, like water. If I make a shield of water on my ship, then I produce very few secondary particles. I stop the [heavy nucleus, such as iron] as it's hitting the oxygen and hydrogen in the water, and as a consequence, I get a very low fraction of very high-energy neutrons coming out. I can again reduce this problem they are worrying about by shielding the ship with the appropriate materials.

EIR: So one of the advantages of a nuclear propulsion system would be to increase the amount of payload you can carry, which allows you to increase the amount of shielding that you have?

Howe: Exactly.

EIR: This is a very important point, because what Bob Zubrin says, is that the only value that nuclear propulsion would have in terms of less radiation exposure, would be if you could get people to Mars more quickly, but that this could not be done with the kind of nuclear thermal systems that have already been tested, such as in the 1960s NASA program, or technologies that have been considered recently. But you are saying that even with near-term [solid core] nuclear propulsion, you have so much greater payload capability—

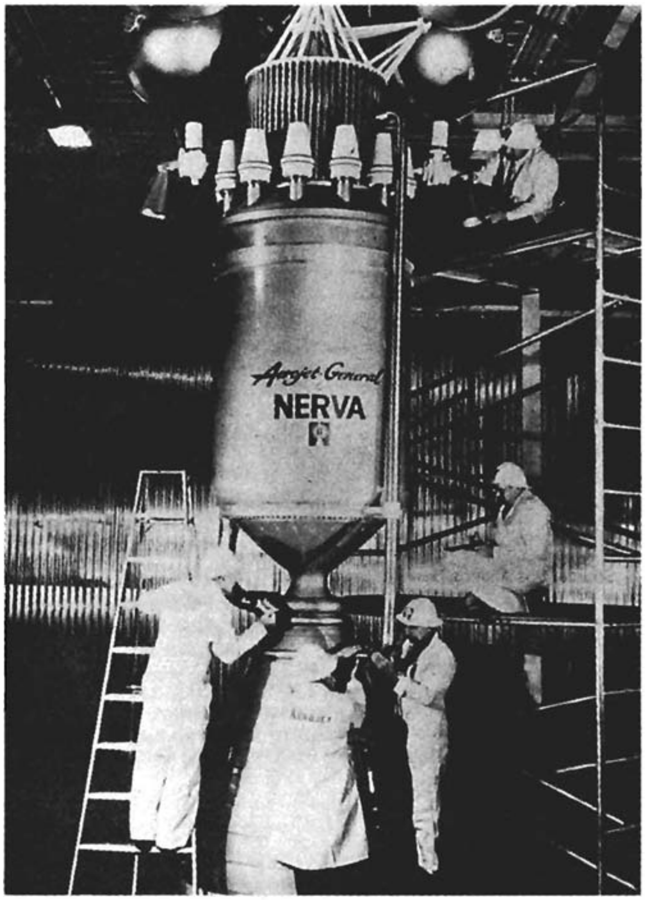
Howe: I can take a shielded habitat, *and* I can go faster. I get both effects, both components.

EIR: Another assertion that Zubrin makes is that while first-generation nuclear systems would nearly double the amount of payload you could take, this does not reduce the flight time.

Howe: I don't know where he gets that. Our studies, which we began back in 1985 and continued through 1991, in conjunction with three NASA field centers, show that it's a trade. You can either increase the payload by a factor of two, or you can significantly reduce the trip time, not by a factor of two, but still reduce it.

EIR: About how much time would be saved compared to Zubrin's chemical rocket missions?

Howe: If you want to go to the extreme for the solid core nuclear rocket, with 1,000 seconds of specific impulse, we believe you could accomplish a one-year round-trip mission. That was on the extreme end of that envelope, using current technologies with the NERVA design. We could do roughly a [one-year] round trip, where chemically, you're in Zubrin's



This full-scale wooden mock-up of the Nuclear Engine for Rocket Vehicle Application (NERVA) helped engineers observe the placement and orientation of components for the nuclear propulsion system. The photograph was taken in 1962. The nuclear reactors used in the NERVA program were developed at the Los Alamos National Laboratory.

three-year-type program. With the solid core, certainly you could do a 400-430 day round-trip mission, with about a one-month stay-time on the planet.

EIR: Zubrin says that if you are going to be making the effort and taking the risk to take people to Mars, you do not want to have only a one-month stay time. What would be the kind of nuclear systems that would have to be developed so you could go on a non-ballistic trajectory, and have the ability to come and go whenever you please, and not be limited to the proper Earth/Mars planetary alignment every 26 months?

Howe: Let me preface this with a little statement that I have equated Zubrin's plan to. You may remember Thor Heyerdahl, in years past. He contended that various early peoples could make low-technology boats and cross the oceans. One of his examples, that I recall distinctly, was the Egyptians, who could make a reed boat and sail to the Americas. And he essentially all but proved this. He could make a reed boat and just barely get there.

To me, this is what Zubrin is talking about. He is taking essentially a low technology; we have better technology than that right now, but he doesn't want to use it. He wants to take a low-technology system that will just barely get there. Whereas, in fact, we have the technology now to almost make a clipper ship, to get there in a few months time frame, in a robust, healthy environment to withstand the storms, and essentially let the crew survive. But I equate Bob's plan to this reed boat idea.

What we are working on right now in the laboratory is the gas core nuclear reactor. This is the next generation, the next step beyond the NERVA.

EIR: Can you explain the difference between the NERVA solid core reactor, and the gas core reactor?

Howe: NERVA had a ceramic core. It was a uranium/zirconium carbide material; a solid material that was graphite based, and it had holes drilled through it, through which hydrogen would flow. As that uranium core grew critical and got very hot—up to about 5,000° or 5,500°F—the hydrogen flowing through came up to those temperatures, became super-heated, and flowed out [as propellant]. The limit to that kind of design is the melting temperature of that ceramic. So you are limited to about 1,000 seconds of specific impulse, which is about two times better than chemical engines.

What we are looking at is, can we, with computational modeling, and a better knowledge of plasma physics, create a stable region that is in gaseous or plasma form, a gaseous core, and is not limited in the temperature that can be achieved? If we can create that by fluid dynamics means—in other words, fluid flow creates the region where the core is held—we can now get to temperatures of 30,000° or 40,000° Kelvin, on the order of 50-60,000°F, and get specific impulses of 3,000 seconds.

EIR: What is the difference in capability, if you can increase the specific impulse that magnitude?

Howe: It is certainly more than just the ratio. As an example, if I double the specific impulse for a standard Mars mission, and want to do the one-year round-trip mission, it would be [an advantage] of a factor of two. For a 3,000 second specific impulse, which is now three times better than NERVA and six times better than chemical, we can start talking about a nine-month round-trip mission, with a one- to two-month stay on the surface. Or, we can trade that a little bit, have a slightly longer mission, and take enough payload to do multiple landings on the surface, or certainly shield the habitat from galactic cosmic rays. So it's a trade: You can trade mass and time, to some extent. But it is certainly on the order of a factor of ten better than a chemical rocket.

I can now do fast, manned Mars missions to the tune of nine months, which is essentially a four-month transit, two-month stay, three month return. It's a Skylab-type experience in zero-g [84 days was the longest Skylab mission], not a Mirtype experience [where cosmonauts have stayed for more than a year].

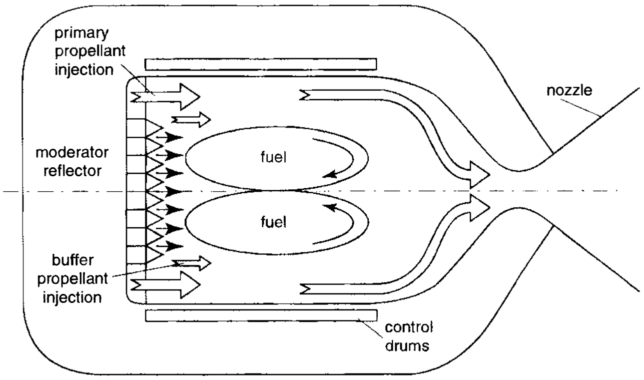
We are looking at alleviating the zero-gravity effects on the body, we are reducing the total radiation dose to the crew, and we're providing multiple landing sites on Mars.

EIR: If you wanted to use that kind of technology and do the trade-off differently, you could maximize the payload capability and develop a series of spacecraft that were transporting only cargo, and go more slowly, because time would not be as critical as it is with people.
Howe: Exactly. The other advantage of the gas core system, since we will probably be losing a small amount of uranium out the nozzle—and that is essentially what our research is geared toward right now, to find out that amount—I can run this reactor for far longer burn times, such as you point out. If I want to do a two-year mission, I can optimize my specific impulse and my burn rate to keep the power down, and burn very long times, and optimize to the mission that I want to fly. It's much more valuable.

The other key advantage of high specific impulse, compared to the others, is that I've broadened my launch window. If I go with a chemical system, I have to launch within a very narrow amount of time to match the orbital lineup of the [two] planets.

FIGURE 1

Schematic of a gas core nuclear rocket in a cylindrical geometry



Source: Los Alamos National Laboratory.

The toroidal fuel vortex is maintained by controlling the injection conditions of the primary and buffer propellants. Nuclear criticality is controlled with the external control drums. The hydrogen propellant is heated radiatively to very high temperatures for expulsion through the nozzle. The design goal of 3,000 seconds of specific impulse has been established.

EIR: You can only launch once every 26 months.
Howe: Exactly. But with the gas core system, I may have plus or minus a month capability, because I can now burn [the engine] a little longer, with a high specific impulse, than I'd planned—or not. I can launch with a lot more leeway if something is not quite right, when it comes time. With the chemical system, if it's not all ready to go, you're in trouble, and you've lost the opportunity for two years. And that's a big advantage, as far as operational considerations, expense, and redundancies are concerned.

One of the major failures of this Zubrin plan, is this 500-day stay on the Mars surface, which I consider absolutely ridiculous, from a crew survivability standpoint. I think that the basic premise Zubrin makes, is that the radiation level on the Mars surface is relatively benign.

EIR: That is what he asserts. He says that once you get to the surface of Mars, you don't have to worry about the radiation.
Howe: And he's just flat wrong. It turns out that as part of the Mars Observer program, we had a fellow here in the laboratory who was going to do galactic cosmic ray-induced gamma ray measurements, using Mars Observer, to look at the elemental composition of the Mars surface. He has done fully three-dimensional calculations of the galactic cosmic ray flux onto the surface, and the resulting gamma rays, and what comes out of his calculations, is that the radiation on the surface of Mars appears to be roughly equal to the Moon, or slightly greater. So if you are going have to shield people on the surface of the Moon, you are going to have to shield the habitat on Mars. That means bulldozers and heavy equipment, which Zubrin has not included in his plan. I think it is ridiculous to think of putting down for 500 days in one place, where you want to really survey the whole planet. I think that is unreasonable.

EIR: To make his plan seem more reasonable, Zubrin keeps adding more bells and whistles to his original bare-bones tuna-fish-can design, so he is projecting that in the missions following the first, the crew would have a rover on the surface—
Howe: This would have a one- or two-hundred-mile radius. It seems to me, you would like to have three places to explore on the equator and one at a pole. To do that, you have to have a propulsive capability in orbit, and that is what the gas core offers. I can take enough fuel to go down and back at least twice, maybe three to four times, depending, again, upon your trade study, and how fast you want to get there and back, versus how much payload you carry. You can't put that much material on the surface, and you can't afford the fuel to do that. So you are going to have these people living in extremely spartan conditions, and you'd rather do that for a week, than a year and a half, or two years. I just don't think Mr. Zubrin has much experience in human operations.

EIR: Bob Zubrin has made a hallmark of his Mars Direct scheme, the use of *in situ* materials on Mars. As you pointed out in an op-ed you wrote with Stanley Borowski, from NASA Lewis Research Center, for *Space News* in August 1994, this is not a new idea. NASA has talked about and envisioned using local resources on the Moon and Mars since the late 1960s, when people started to plan these missions.

In his book, *The Case for Mars,* Zubrin includes something which he does not mention in many of his more popular articles and presentations, when he talks about the use of *in situ* materials on Mars. He states that the only efficient way to make the methane rocket fuel from the Mars atmosphere, is to use nuclear power. He asserts that a small, 100-kw-electric SNAP-type stationary nuclear reactor could be developed over four years, for $500 million to $1 billion. He said that previous studies have projected that it would take $6 billion over 12 years, for a large nuclear system, but he only wants a small one. What is the reality of the situation?

Howe: In reality, I don't think Mr. Zubrin knows what he's talking about. To quote you some numbers. . . . You can't just scale up the SNAP from the low power level that it was originally built for. SNAP was done in the 1-10 kw range. Building and testing any nuclear reactor in this day and age requires an extensive test facility and several years, because if you want this to last two years, you have to put it under the correct Martian conditions and operate it for at least *twice* the operational lifetime. So you have to have a test facility, a total containment facility, where this reactor is up and running for at least two years, twice that, and that is assuming nothing goes wrong. To say that it can be built in four years, at a half-billion dollars, is just unrealistic. He hasn't been involved in nuclear development programs.

The SP-100, which was supposed to be the state-of-the-art technology, was still going to be a billion and a half dollars and probably on the order of a five-year development program. That wasn't designed to operate on Mars; neither was the SNAP. You can't take an SP-100 and put it on Mars. They were built to operate in free space. So you're going to have to change the design, and that means you've got to do developmental tests, and that means that the life of the program is extended. That is for the electric [power reactor].

His comment about the small nuclear rocket engine—during the Space Exploration Initiative in the early 1990s, NASA and Los Alamos and INEL at Idaho sat down and tried to trim everything we could to recover the Rover/NERVA technology. A lot of this gets into what NASA would accept as far as assurity, or the criteria that we use now to proclaim it to be tested.

EIR: Do you mean that the criteria that were used when it was developed wouldn't be applicable today?

Howe: For example, when NASA accepts a new chemical engine, they have to have 50-some tests performed on that engine for various times and restart conditions. To do that with a nuclear system is probably unrealistic. The question was, what would NASA define as qualification criteria? We had to make some guesses and assumptions in that respect. But the best number we could come up with was on the order of $1.5 billion and on the order of five to seven years to recover the [1960s] Rover/NERVA technology, and have a *tested* system in orbit, that would be flight ready. So, this idea that you could do something for half a billion in four years—I think Bob just hasn't been involved in those kind of systems. He doesn't understand the details and steps you have to go through to get to that. That's just unrealistic.

There is one other point I haven't heard expressed yet, in terms of the problems with the Zubrin idea, which is what I would call operational problems. You could talk to the flight people at Johnson Space Center, who try to get complex systems up-and-running on a deadline, in order to execute a mission. As I understand the Zubrin plan, he is going to send a million-dollar factory onto the surface of the planet to create fuel [for the astronauts' return flight], prior to the manned launch.

Glossary

SNAP—Systems for Nuclear Auxiliary Power. The SNAP program included the development of nuclear generators for providing nuclear energy in space. The SNAP-10A system was successfully tested in Earth orbit in 1965. In total, six reactors were built and tested, but the program was cancelled in the early 1970s, when manned missions to Mars were no longer under consideration.

Rover—The NASA effort to develop nuclear technology for space propulsion was gathered under the Rover program. The earliest research reactors in this program were named Kiwi, which were designed to establish the basic nuclear rocket reactor technology. Other systems tested specific aspects of nuclear technology, up through NERVA.

NERVA—Nuclear Engine for Rocket Vehicle Applications. NERVA was NASA's program to develop a nuclear rocket engine for lunar and interplanetary space flight. In June 1969, the NERVA-XE rocket engine was tested at close to full power of 50,000 pounds of thrust, for the first time, and was shut down and started 28 times. Despite its success, the program was cancelled in 1973.

Specific impulse is a measure of the efficiency of a rocket engine. It is the number of seconds a pound of thrust will be produced by a pound of propellant. The higher the specific impulse, the greater the potential velocity and payload capability that will be obtained by a spacecraft.

There are two problems with that. One is that such a factory, which is probably 100 times more complicated than a Galileo spacecraft, to produce the material, and liquefy and store it in a tank, under Martian conditions, is a complex operation. When you have a problem equivalent to the Galileo antenna not unfolding, or the solar panel not unfolding, what does that do to this complex factory? So, there is a problem in sending up complex robotics, when we can't even get small satellites to operate in a fool-proof manner.

But, he says, that's okay, because we're going to have a little light here, and unless this fuel tank is full [with fuel that it made on Mars, for the astronauts' return trip], and this light lights, we don't launch [the crew from Earth to Mars]. So what you're saying is, I'm going to now train an astronaut crew for probably 5-10 years prior to this mission, and we're going to wait for that fuel tank light to light up.

What happens when you get to the launch, and that light isn't lit? You can send another factory up, because we can't repair the one that's up there, and then wait another two years, to see if it can get its job done. And if, by some chance, because of some fundamental design flaw, like the Martian dust gets into the cracks and makes the machinery break, you find yourself at that point, and you can't launch the human crew, because the return fuel isn't there. Now you have to start all over and develop the technology that you said you didn't have to—to get them there and back in one ship. Wouldn't it make far more sense to develop that technology in the first place? Because operationally, this is illogical. You are just asking for failure, because you can't repair it.

Alternatively, you could send the factory up there, send the human crew with their return fuel, and have them tinker with it to make it work—have them tighten the bolts and clean the filters, and make sure the thing is functioning. And then, after it's filled the tank a couple of times, it starts to reduce the cost of your sending follow-on missions. That, I might buy, but certainly not as the first mission.

EIR: Even Zubrin admits in his book, when he discusses advanced nuclear propulsion technology, which he sees being developed *after* the first manned missions to Mars, that its cost will be amortized over many flights, because, unlike a chemical rocket, you don't throw it away after each mission. This is reusable, so it is similar to building a highway; you don't tear it up after the first few cars go by, you expect to use it for the next 50 years. The capital cost is amortized over time. But he doesn't see using more advanced nuclear propulsion technology from the beginning, because he is tied to this artificial ten-year time table.

Howe: Let alone, the other missions that it enables to the outer planets and the other things you could do when you've developed the technology. [Advanced nuclear technology] reduces the cost of all future missions. You have to weigh that in. You have to see if it is worth a few billion dollars to develop the technology that opens the Solar System. A few billion dollars is a small fraction compared to the total mission cost. His $20 billion [for Mars Direct], I think, is an absolute fantasy. I think he's totally way off on that.

He uses what I call "comic book physics." He just draws a picture and says, "I'm going to go steal a couple of existing engines and make a heavy lift launch vehicle." That's, again, fantasy. I'm surprised, to be honest with you, at the public acceptance of this. I'm also suprised with the idea that the public is ready to do this on the cheap and skimp at it, thinking that we can glue something together, and it will work. I don't think space works that way. This is a hostile environment, and if you're willing to accept that it's going to be expensive and it's going to be hard, just as Kennedy said, we do it *because* it is hard, you must be ready to commit the resources to do that. We can't do this on the cheap, or these guys aren't going to be coming home.

EIR: I would caution you not to make the mistake of thinking that what the media report is what the American people think.

Howe: That's a good point. But I do assume that, since so many shows are being broadcast with Bob's picture in them, the media must have some indication that it is being accepted, or they wouldn't keep making them.

EIR: The media can play on the enthusiasm the public has for the space program and promote various schemes such as this one.

Another assertion that Zubrin makes in his design, is that it is a waste of energy, time, and resources to go back to the Moon. What is your view of this, in terms of nuclear applications for space exploration?

Howe: I see the Moon as making two major contributions to going to Mars. One is very intangible, and one is quite tangible, I think.

The intangible one, is that I believe if there was a functioning lunar base on the Earth-facing side of the Moon, and it was constructed correctly, so there was a gleaming light, so that every child who grew up henceforth and walked out in the night sky could see that humans were up there working, it would change his whole psychological outlook, as far as his actions down here on the Earth. That when grandpa goes out there with a grandchild and sees, and says, "There are people up there," it's a bright spark of hope in the future. It changes your whole view of what is coming. And that is the intangible. I claim that the lunar base can provide that. Whether you are in Australia, or Nigeria, or Canada, or the U.S., throughout your whole life, you saw people up there. So that's the intangible benefit. And I think it's a very valuable and important benefit.

The tangible benefit, is that no one has ever put a group of people in a confined space for a long period of time where they could not be rescued, or extracted from it. The psychology of that group in that condition, is totally unknown. The Moon provides that more than Antarctica does. The base at

Antarctica has a large crew, where you can have a social function, but in space, you would put six people in a very tight situation, where going outside means death, and you can't just turn it off and say, "The experiment's over, you can come home." That's what the Moon provides; all of our life support in a full-up, full-duration-of-the-mission test run. Those are the first two things I see, and they are more psychologically oriented than technologically oriented.

From the technology side, clearly the Moon offers the opportunity to do experimental testing of nuclear propulsion. There is probably going to be large resistance, or it is going to be a very expensive prospect, to do full-scale nuclear tests of a nuclear propulsion system.

EIR: On Earth?
Howe: Even in Earth orbit, potentially. We do think that gas core [reactors] offer the advantage, where the first time we do a full-power nuclear test is in orbit, and maybe we don't have to build the humongously expensive test facility on the ground. But if you have an active lunar base, it would be even more advantageous, because I can now access the engine while it is being [static] tested. Whereas, if I do it in orbit, once I light this thing for any length of time, it's gone.

And you want to do a long enough test to really come up to power and speed, and you are going to develop enough delta-v, so unless you have it attached to a big mass, it's going somewhere. So, the Moon is ideal, in that respect. All of the effluent will be blown out into space, as it is clearly above the escape velocity of the Moon, so you wouldn't perturb the environment there, but it is accessible. From a technological standpoint, it is a big benefit. Of course, you are only three days away, so if there were a life-threatening situation, and you were willing to pay the expense, you could save them. I do think the lunar base is the next step.

Personally, I think the lunar base probably can and should be developed by private enterprise. It should be done as a commercial venture. Then, the U.S. government would simply hire the company to perform the tests pertinent to the Mars mission. Some conglomerate of companies could get together, put up a functioning lunar base, and man it, with industrial-type safety standards, instead of government safety standards, and then the U.S. government, if it decides to do a Mars mission, simply contracts them to perform various tests: the psychological, or the nuclear. I believe that the Moon is close enough that there are enough opportunities to make a profit, that private companies should do that part of it, and the U.S. government should hire them as part of the program to go to Mars.

EIR: Because of the "faster, better, cheaper" approach of current NASA Administrator Dan Goldin, the lunar studies that have been done recently have been based on the idea that there will be no development of new technologies.
Howe: Exactly. You put a can on the surface. So what?

EIR: Wouldn't you also want to test stationary nuclear power sources on the Moon, to produce electricity, in addition to testing nuclear propulsion technologies?
Howe: Again, that's my whole premise. The benefit of space exploration is the development of new science, new technology; that, then, is reflected into everyday human existence. The [recent] NASA technique for the manned [return to the] Moon just didn't do it. My argument is that you send up people with the tools that they need to make the things they want, not the things themselves.

We developed technologies here [at Los Alamos] for example, to extract not just oxygen, but also sulfur, from the lunar soil, and sulfur combustion is a very viable source for propulsion or fuel cells. We looked at microwave processing of lunar soil into ceramics and glasses. You can build everything you want out of local materials, if you're power-rich and send the right tools. I've written a book about this which is called *Honor Bound. Honor Born.* The whole premise here is that it is a power-rich entity. It is a one-man effort to get started, and you utilize all the local resources to add on a greenhouse. The glass you make can be translucent, so it stops galactic cosmic rays but lets sunlight filter through. I use a subterrene to drill, which is a technology we built here.

As Krafft Ehricke said, way back at the conference on Lunar Bases and Space Technology for the 21st Century [in October 1984], "If God wanted us to go to space, He'd have given us a Moon." It's clearly the first step. Unless you can survive there and work there and operate there, going to Mars for a length of time shouldn't be done.

You're also exactly right, that the other key technology to develop is nuclear electric power. You want a power plant that sits there and cooks out electricity and doesn't need tending. It doesn't need fuel, it just sits there, and when you plug in the socket, the electricity is there. This is the one area where Zubrin and I do agree—you need a nuclear reactor for an electric source. I disagree with how fast, and how much, and his claims that you can build it that quickly, but I do contend that it is a necessary component for planetary exploration.

EIR: Even if we confirm that there is ice at the south lunar pole, we have to develop techniques for processing materials that are not reliant on water, which is the way everything is done on Earth. What you are going to substitute for water is electricity, turned into microwaves, or other directed energy.
Howe: Exactly right. That is what I call a power-rich environment. You want far more electrical power than you think you are going to need, because you will end up using it in developing those processes.

EIR: There have been a lot of disappointments in the research in space nuclear power, including the cancellation of the SP-100 program. What activity or research is being done now?
Howe: As far as I am aware, the last program was the Topaz

study, the joint effort with the Russians in Albuquerque. I am not sure, but I think that was supposed to shut down last fall. As a consequence, there is no space nuclear project of any kind going on.

My opinion, on that particular program, was that it was not of much value. The reactor was a 20-year-old technology, it was a 6-kilowatt power level, so it really didn't have any application in the space program. In order to build one that would have applications, you would have to redesign the whole thing. To test out the idea of thermionic conversion—the Russians have already proven that, time and again. In my opinion, that was an "admirals-type" program. It was there for publicity. I am sure they did extract some very good scientific research out of it, but if you really wanted to do space nuclear power, that probably wouldn't be the thing you would do.

EIR: At the time, there is probably little space nuclear research that the Russians are funding, but they have a very significant capability. Would a joint program be worthwhile?

Howe: If carefully tailored. In other words, I think the U.S. should develop its own technology base. You don't want a critical factor, like a test facility, to be over in Russia, where you might be terminated in your access to it. A critical component can't be part of the program. Clearly a parallel effort, and a collaborative effort, as far as the research and the science, is desirable. They have spent far more years in the solid core nuclear program than we have, although maybe not as much money. The have probably put more effort into the gas core historically than we have, and certainly they have developed the thermionic conversion system for space nuclear electric. There is a database, and knowledge base, and expertise there, that should be recognized in the scientific sense, but as far as the hardware, I think that should be stationed here. You can walk in parallel, but separately. Hardware compatibility and integration is an extremely difficult problem. You want to share knowledge, not resistors.

EIR: Is there anything else you would would like to add?

Howe: Just to summarize: I believe that if you are willing to undertake this challenge, and you have the science and the technology that allow you to attack the problem, you must use them. For example, even from a legalistic standpoint, if you sent this crew on a chemical-propelled system and they all died, and you had a better technology available to you, are you now liable? Are you not ethically required to give it the best shot you can? By doing it "cheap and simple," you're evading the problem. If we want to go into space, we must accept the challenge and do it right. Unless you're willing to do that, you've got no business trying.