THE STRATEGIC DEFENSE OF EARTH

Asteroid Defense and Fusion Propulsion

by Ben Deniston

Nov. 25—Two members of the LaRouchePAC Basement Research Team, Benjamin Deniston and Jason Ross, attended the Fall 2012 NASA Innovative Advanced Concepts (NIAC) Symposium, Nov. 14-15, 2012, held in Hampton, Va. NIAC operates under the NASA Office of the Chief Technologist, and provides funding for studies of advanced and innovative space technologies critical for NASA missions in the next 10 to 100 years. The future perspective of NIAC brings together many interesting participants, with applications ranging all the way from exploration of the Solar System, to investigations pertaining to fundamental physics, to innovations in materials and production. Videos from the symposium can be found on NIAC's website.

Deniston and Ross interviewed three of the participants on their work on asteroid defense and on fusion propulsion, areas of vital concern for the defense of Earth and the expansion of mankind into the Solar System.[1]

Professors Bong Wie (Iowa State University) and Brent Barbee (NASA Goddard Space Flight Center) spoke about defending planet Earth from small to medium-sized asteroids when we have relatively little warning time before impact. Their "Hypervelocity Asteroid Intercept Vehicle" concept would be a two-part spacecraft, designed to operate at very high intercept speeds, utilizing a thermonuclear explosive device to break apart the threatening asteroid.

Dr. John Slough (President and Director of Research at MSNW) discussed new designs for a fusion-powered

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Professors Brent Barbee (center) and Bong Wie (right) are interviewed by LPAC's Benjamin Deniston at the Fall 2012 NASA Innovative Advanced Concepts (NIAC) symposium.

1. See the LaRouchePAC reports, "The Strategic Defense of Earth" and "IGMASS: Towards International Collaboration in the Defense of Mankind."

spacecraft. Using current chemical propulsion systems, a round-trip human expedition to Mars would take two to three years. On such missions, astronauts would lose both muscle and bone mass, and would be exposed to large doses of cosmic rays and energetic solar particles. The cargo required for such a mission would require nine launches of the largest-class rocket for a manned Mars mission. Dr. Slough's team of researchers at the University of Washington and MSNW, believe they have a unique solution to this problem by using nuclear fusion. The high energy density of fusion fuel means that such a rocket could reduce the trip time to 30 days, while requiring only a single rocket launch per Mars-bound spacecraft.

The interviews follow.

Interview: Brent Barbee and Bong Wie

SDE: Hypervelocity Asteroid Deflection

Professors Brent Barbee and Bong Wie were interviewed at the NIAC symposium by LaRouchePAC Basement scientific researcher Benjamin Deniston on the question: "Asteroids and comets will strike the Earth in the future, so what can mankind do to defend itself?"

Brent Barbee: My name is Brent Barbee, and I'm a flight dynamics engineer at the NASA Goddard Space Flight Center. I also teach astrodynamics at the University of Maryland at College Park.

Bong Wie: And my name is Bong Wie. I'm the Vance Coffman Endowed Chair Professor of Aerospace Engineering at Iowa State University.

Ben Deniston: To get started, maybe you could discuss the general concept of asteroid defense. First, why is it an area of concern? Why is it something we should be studying now, as an interest for the scientific community and the population generally?

Barbee: Well, asteroid defense is a very important topic because we know that our planet has been struck in the past by large and small impacters that have done damage to the ground. At present I think there are on the order of 170, 180 confirmed impact structures that have been found all over the world. Of course, most of our planet surface is covered with water and weathering and geological processes that have obscured the signs of impact, but we're discovering them; we know that they're there. So we know that it's a threat that is out there, that we're going to have to deal with.

So, it behooves us to be prepared ahead of time, so that we're not scrambling to slap together some sort of hastily prepared defense at the last moment, when we discover a threat. It's much, much better to have investigated the solution, tested it, done many dress rehearsals, so that we're very, very comfortable and very adept at doing it, when the day comes that we have to call upon those systems to stop an asteroid impact.

Deniston: Because there are a few layers to the discussion, correct? There's observation, detection, finding all the possible threats. And then there's also the issue of mitigation, of doing defense against something that might be a threat to the Earth. Is that correct?

Barbee: That's right. Absolutely. In fact, you could say that planetary defense rests on a tripod of detection, characterization, and mitigation. So, if we have wonderful mitigation systems that are highly capable, but our detection capabilities are poor, then we will be well able to do something about the problem, but we won't know that it's coming. Whereas if we have wonderful detection systems, but no preparation for mitigation, we may very well see it coming, but be unable to act.

So, it's important to have both systems; and historically, up to this point, we've invested a lot more in detection, because it's something that we could do from the ground, using telescopes, and it's been a very successful effort, but now the time has come to begin appropriately, devoting appropriate resources, to the mitigation/preparedness problem as well.

Wie: If I may emphasize that for mitigating the impact threat of asteroids, detection is a necessary condition, but it's not sufficient. And we do need to develop mitigation techniques in order to be ready whenever needed.

The Asteroid Threat

Deniston: Here we are at the NASA Advanced Innovative Concepts conference, and so what exactly brought you here to present something to this particular audience, relating to the asteroid threat?

Wie: We proposed a concept called Hypervelocity Asteroid Impact Vehicle, to the NIAC program, and this proposal was selected, because NASA felt that it is

NASA

To counter the threat to Earth from asteroids, meteors, and comets, both detection and mitigation systems are needed. Shown: an artist's concept of a Multi-Mission Space Exploration Vehicle (MMSEV) approaches an asteroid.

the next logical step to move forward to develop our own national protection system against the impact threat of asteroids. So, we are here to present our concept, and my Co-I [co-investigator] Barbee and myself, we were very pleased to receive constructive comments from our colleagues who are attending this conference.

Deniston: Maybe you can describe why you need to do the work you're doing. Because most people might think, well, we'll just throw a bomb up there and hit it with a bomb—but as you presented earlier, it's not quite that simple. There's actually highly complex science involved in this question, this challenge. So maybe you could present a concept of what exactly you're bringing to the discussion here.

Barbee: Sure. The reason that it's not as simple as just throwing up a bomb—the reasons are multifold. On the one hand, you have the orbital mechanics, so orbital mechanics means that you can't just send the spacecraft to the asteroid for a rendezvous mission whenever you like. There are going to be certain times when you can launch, and have a low relative velocity, naturally, when you get to the target, and thereby effect rendezvous using a reasonable amount of propellant.

So, for our study, we're saying that we want to be ready to deal with short warning-time scenarios. We want to be able to launch essentially at just about any time. So that means that our system has to be designed to come in fast at the asteroid, [at a] high relative velocity at the time that we intercept the asteroid. So, we're not going to carry a propellant to slow down, because physics dictates that that amount of propellant would be huge.

So, our system is designed to come in at an excess of 5 kilometers per second—5, 10, 15, 20, up to 30 kilometers per second—relative velocity at impact. So, what that means is that we're coming at the asteroid really fast.

Deniston: For our audience, that's tens of thousands of miles per hour, correct?

Barbee: Oh yes, tens of thousands of miles per hour. So, I think, as a reference point, 7 kilometers per second is on the order of about 20,000 miles per hour—something like that, so yes, that's right. And as we're coming in, the asteroid starts off as this little tiny dot that the cameras on the spacecraft can just barely see, a few million kilometers away; and then, within a matter of hours, we're down to the last few minutes, and the last few seconds, and we cover hundreds of kilometers within a matter of a minute or so.

So, there's very little time for the spacecraft to react. So, we have to design robust on-board guidance, navigation, and control systems that can successfully hit that relatively small asteroid out in the huge volume of space, traveling at such high relative velocities.

What's more, is that in order to effectively disrupt the asteroid, our design calls for a two-body vehicle: an impacter and a follower. The impacter excavates a small crater, shallow crater, on the asteroid's surface, and then, within perhaps a millisecond after that crater is excavated, the follower spacecraft, which is just behind it, enters that shallow crater, and at that moment, must detonate the explosive device in order for it to be effective. If the explosive device were to strike the surface of the asteroid before detonating, it would be destroyed, and the mission would be a failure.

So, there are some very precise timing [issues] and a key sequence of events that will have to happen at hypervelocity, driven by robust, cutting-edge new sensor technology, to make all of that happen, and make it happen in a reliable way, so that we know that we can build five, six, seven of these systems, and deploy them, and have high confidence that they would work as designed.

Hyper-Fast Speeds

Deniston: So, you're talking about just incredibly fast speeds and incredibly accurate timing, to be able to have this go off, in just the right fashion; and obviously, this is something where, if we were to encounter a situation where we needed this to work, *we would need it to work!* We couldn't—we would need to make sure this is 100% effective, and have the effect we need.

Barbee: These relative velocities that we're talking about are beyond what we can currently test in terrestrial laboratories. I mean, there are facilities with rail guns and light-gas guns that can get up to the range of 3 to 5 kilometers per second, maybe a little bit more.

But for the regime of speed that we're talking about, it's a very unexplored region. What happens to the materials that the spacecraft is made of? What are the consequences of those materials' effects on the payload that we're trying to deliver to the target? There's a whole host of issues that we have to research. The materials science, the structural design, the hypervelocity-impact physics, and of course, the robust guidance navigation control happening on a very, very short, almost infinitessimal time frame.

So, there are several aspects to this research that are really pushing the boundaries of what's been done.

Wie: But to give the feeling of that high speed, let's say 10 kilometer per second, or even 11 kilometer per second, on someone flying an airplane, that will be more like landing an airplane from a cruising altitude of 36,000 feet, which is about 11 kilometer altitude, in one second, and landing on the runway. That is the kind of speed we don't usually talk about for airplanes. But in space, that is a common speed.

So, currently, we do have guidance navigation-control technology which can provide a reliable precision of an impacter against asteroids. But we have not demonstrated our capability against a small target—50-meter or 100-meter small size. I mean, that is our research goal. The goal is to develop flight-proven technology to be ready to be used, for a small 50-meter, 100-meter target, with a very short warning time.

Deniston: I know when it comes to a discussion of mitigation, there's a complex number of scenarios and questions. You mentioned that you are specifically looking at short warning times, because the idea is, if you have a longer warning time, there's an array of methods you might be able to use. You might be able to kind of bump it, or impact it with a non-explosive device. You might be able to pull on it gravitationally, or by various other means. But you're focusing on a very specific scenario, where we might only have months, in the range of months, warning time, right?

Barbee: Even up to several years. Really, anything less than ten years falls into the range of scenarios where you would need to use some kind of a nuclear solution. The NRC [Nuclear Regulatory Commission] report that was released several years ago, sort of identified that range of warning time, from ten years down to zero, essentially, as being the regime in which you need to have some kind of a nuclear solution. Because of the energies involved.

Deniston: And that's why I want to ask, just to illustrate for people: Because when you're talking about the energies needed to have an effect on these bodies—you're talking about mountains, basically, mountain-sized rocks and debris flying around in space—the energy density you get with nuclear and thermonuclear capabilities is just orders of magnitude more than you get otherwise. Is that correct?

Wie: Yes, that's correct. Also, I'd like to emphasize that we don't have correct definitions of a short warning time. Everyone has a different time scale. So, as we said, even a ten-year warning time, we consider short. So let's assume that we have ten years lead time, but if it takes nine years to make a decision for the launch, then we have only one year engineering lead time, that is not sufficient.

So that's the situation right now. We don't have a clear definition of what do you mean by warning time. Does it include political decision time? Or do we have a system to be launched right now? Do we have to find a launch vehicle, or do we need to design a satellite? So, that is an open issue to be further studied, to be discussed.

International Collaboration

Deniston: I wonder if you also could speak to the idea of international collaboration, because obviously, the first thing that comes up with this, is—these asteroids, they don't distinguish between NATO countries and non-NATO countries, or which economic bloc it's going to impact somewhere on the Earth. This is a global threat that transcends a lot of national boundaries, obviously.

You know, we're interested in collaboration with, especially Russia and China, for example. This should be an effort where we should be pooling the scientific capabilities of the best nations of the world, and I was wondering if you had any thoughts on the importance of that aspect of the threat.

Barbee: Well, planetary defense, for all the reasons you just said, would be a wonderful thing for all the people of the world to cooperate in. That would be fantastic. But until that day comes, there are going to be some pretty thorny issues that have to be dealt with.

For example, if you have an object whose diameter is 1 kilometer or larger, when asteroids get to be that big, or bigger than that, that's when you really have the threat of global consequences from the impact. For things smaller than that—when you're talking about a several-hundred-meter asteroid, maybe a 100-meter, 50-meter asteroid—the effects of those impacts, while still devastating, are on a more localized scale. We'll know ahead of time, when we've spotted the asteroid coming, what are the possible impact locations on the Earth. And so, if it's going to be impacting one region or one country, and it's only going to affect them, then who's responsible for building and deploying and managing the deflection mission, if that country's not capable of doing it themselves?

Those are the kinds of questions that are going to be asked.

And then there's the question of liability. Who's liable if the effort fails, or if it makes the problem worse than it was to begin with? So, the questions of responsibility and liability really rise to the top, when you're talking about this small several-hundred-meter, down to maybe 50-meter, asteroid size in range, which is difficult to deal with, but it's something that really has to be thought about, because the smaller asteroids, between 50 and several hundred meters in size, are more numerous than the very large kilometer-sized and larger asteroids.

So, it's much more likely that, within any given time frame, we're going to be faced with the threat by one of the smaller asteroids than one of the very, very large ones. So, it's something that we should. . . I don't know what the answer is, but these are some of the questions we need to start thinking about for the first steps in international collaboration.

The Big Picture

Deniston: As a last question, let's take it to the big picture. Say, we live on this planet. If you look at it on the scale of the Solar System, it's a relatively small location. Our Solar System is located in this entire galactic system. Here, we've got records of the history of life coming and going on this planet, mass extinctions, major extinctions; some we think are related to asteroid impacts, others maybe to other events—global climate changes, maybe supernovae, all kinds of things that go on in our environment that tend to be in an area that's, say, above the heads of most of the general population.

But it seems like taking on this issue has some rather profound philosophical, cultural implications for what this means for mankind, to actually consciously take on a challenge like that. And I wanted to know if you wanted to speak to any of these bigger-issue pictures that are related, when you bring in questions of tackling these types of challenges.

Wie: Yes, I agree with you that there are many other natural disasters that we cannot do anything about, to prevent those events, but the impact threat by asteroids can be detected in advance, and probably such an impact threat can be prevented, because we have the technology. But the technology is not quite ready. And we need to develop those technologies which can be used when they are needed, at the right time, in the future.

Deniston: Any last comments?

Barbee: Well, it's true that asteroid impact is probably one of *the* most serious natural disasters that is, in principle at least, preventable. And so, it seems to me that for any species that's going to survive for a very long period of time, such a species would almost certainly have to make the deliberate choice to learn to protect itself from any extinction-level event, and that, if we, as human beings, are able to make that jump, and make that decision, and make that choice, that bodes really well for long-term survival.

Not just because of stopping the asteroid from hitting, but for what that means about us as a people, and us as a species, that we're able to have the forethought and be willing to behave cooperatively towards that end—that, in and of itself, regardless of the technology to deflect the asteroid, that decision, that choice, means a lot for our future.

Interview: John Slough

Developing Fusion Rockets To Go to Mars

Jason Ross of the LaRouchePAC Basement scientific research group interviewed Prof. John Slough, president of MSNW, on his firm's proposal for a fusion-powered rocket, with the ability to get man to Mars much more quickly, without exposing astronauts to the hazards of space and other dangers.

Jason Ross: I was hoping you could just share with our viewers a general idea of what your idea is, with your fusion rocket.

John Slough: We perceived that the problem with why we're not on Mars now, is that it costs too much, and it takes too long. So, the only way that those two problems can be addressed, is if we manage to have a rocket, where the ratio of the mass of the rocket to the power it delivers is very small. And at the same time, the exhaust velocity must be much higher than what we can achieve with chemical energy, in order to shorten the trip time.

So both of those are required to reduce the amount of material that you need to bring into space, and the time it takes to get there.

There's probably only one energy source that has that kind of energy density, if you want to call it that, and that is nuclear. And now nuclear fission has been a problem for space transportation, but there, they can only use thermal energy that's derived from the fission due to the nature of the reactor/reactions itself. [But] fusion has always held the promise of being able to generate particles at very high energies, and we can then use these particles which have a very large exhaust velocity.

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Prof. John Slough (left) is interviewed at the NIAC conference by LPAC's Jason Ross.

What we've decided is that the fusion process itself, can create a tremendous amount of energy, and that if it were surrounded by a different propellant, other than the fusion plasma itself, that we could then transfer that energy to that material, and then achieve both the high velocity that we need for rapid transportation, and reduce the mass cost, because we actually use the propellant to compress the plasma to fusion conditions. So, we kind of do double duty there.

So the energy that's released by the fusion event goes directly into propulsive motion, rather than passing through some kind of an energy-conversion system, such as a boiling-water reactor, or a boiling-lithium reactor, or whatever you might imagine for space.

It's a very simple system. It is really kind of based on nuclear devices that were developed in the '50s for much different purposes, but the challenge was to not have high yields, like you would see in a hydrogen bomb, but to bring that down to a scale where essentially that energy could be created and transferred to the rocket ship without damage to the rocket ship.

And we believe that we can do this for two reasons. One, we reduce the energy by about a factor of a billion over a hydrogen bomb—you may not even think that's quite enough, but actually it is. The other thing that's very important about the way we proceed to make the fusion event, is that we use a magnetic field to induce this lithium, the preferred material, as the shell that implodes our plasma, and creates fusion conditions. We use magnetic fields to do that.

The good part of that is that after we've created this large burst of fusion energy, and transferred it to the lithium propellant, the lithium propellant becomes an ionized gas itself. And the magnetic field then guides it out the end, so that it can't restrike against the rocket surface. All chemical rockets depend on the wall transmitting the impulse in the nozzle to exit in a specific direction, so here, we avoid the energy transfer to the rocket, and we protect the rocket, all done at the same time.

So, all these things coming together mean that we can now have a rocket ship mass that is, compared to the power produced, a very small number. So, we don't spend much mass in producing the energy. So, that's sort of the basis behind the fusion-driven rocket.

MSNW

The only reason we are not on Mars now, Slough said, "is that it costs too much, and it takes too long." His firm, MSNW, is developing a fusion-powered rocket, shown here in a artist's concept, to solve that problem.

The Low-Hanging Fruit of Fusion Reactions

Ross: Okay. Let me ask you, in regards to the fusion process itself, your plan uses DT [deuterium-tritium] fusion.

Slough: That's right.

Ross: There was some talk about using helium-3 as a potential source for aneutronic fusion reactions. What are your thoughts on that, in space and here on Earth?

Slough: One thing we found—and this has always been sort of a bias against fusion using DT—it's obviously the easiest and most energy-productive way to create fusion energy. The DT reaction has the largest cross section, has the lowest plasma temperature, so it's what I call the low-hanging fruit of all fusion reactions. And all conceptual designs for Earth-based reactors are always based on DT for that reason.

Now, helium-3 would be an interesting alternative propellant, but the problem there is, it doesn't exist naturally—it's only produced by the decay of tritium. Tritium itself is also only produced by man-made reactions, but the process that's required for making it aneutronic requires a much more difficult fuel to actually convert into fusion energy.

But the real problem that I see is that, having neutrons is only a problem in an Earth-based reactor, in that you need to shield it. In space, in all but the small direction that the spacecraft takes in terms of the solid angle, the neutrons just fly off into space, harmlessly.

So, neutrons aren't bad. Neutrons are actually good, in that they're volumetrically absorbed, meaning that when we try to heat our propellant, in this case the imploding shell that surrounds our plasma to bring it to the fusion condition, the whole body of that absorbs it, and so we can heat the entire mass, and that way convert it all into an ionized gas.

If it were trapped in the form of particles, the particles themselves would be retained in the plasma, and then you have the problem of, how do you get the heat out? So, maybe for a terrestrial reactor, it might have some benefit—I'm not sure about that either. So, neutrons are good as far as I'm concerned.

Ross: Okay, so they're overly maligned.

Slough: Yes, that's right. Well, they obviously can modify and transform materials, and that is good, because that means you can create the fuel that you need, the tritium fuel, from the reaction itself. The other reason people fear neutrons is that they are the means by which a chain-reaction occurs in a fission reactor, so I think they've gotten a bad reputation from fission, but not so much from fusion. So, we'll see.

But transforming materials could be another application, using waste from fission reactors.

The Orion Project

Ross: Right. Your proposed design uses a pulse-propulsion technique similar to, say, the Orion project that was studied earlier in the U.S. What could you say about Orion as an inspiration, or about international work on nuclear rockets of this sort?

Slough: It's true: There was a lot of time and energy spent in trying to use nuclear energy in a way that they knew would produce the copious amounts of energy required for space travel. And the Orion project, unfortunately, at that time, was too close to the concept of an atomic bomb to find any widespread acceptance. In fact, it was banned by all countries.

But the main problem with fission is that, in order to get enough fissile material together to have a chain-reaction that will produce these sort of energies, it requires a very large amount of mass, and therefore a very high amount of energy release. So, the amount of energy release couldn't be reduced by a billion the way we'd like to do with the fusion reaction.

A fusion reaction can really occur at any scale, and that means it's scalable down to a level that we can use it. So, the only successful demonstration of fusion has been with the pulse systems, so we felt like it's got a firm grounding there in the fact that, at least there are several countries that know the process.

Now this is slightly different in that we intend to use a magnetic field to confine it, and that allows us technologically to make it much simpler. So, there have been studies done in terms of the implosion technique that we intend to use with magnetic fields in other countries, particularly back in the Cold War days. So a lot of that information, I think, is now lost, because of the retirement and death of the Soviet physicists, but also, just simply, these things were not written down. But there's a great body of knowledge, worldwide, on how to maybe do this.

So, I think if we can have a demonstration of its potential, through a successful implosion, which we can do in our laboratory, that we'd probably find worldwide interest increased in this process. Because you could also, needless to say, use it for terrestrial energy generation.

Under the Radar

Ross: Let me ask you one last thing, then. Sometimes these projects are discussed, as to whether it's a question of the scientific feasibility versus the political will, which means funding.

Slough: That's right.

Ross: Those might not actually be different questions, since scientific breakthroughs occur when you have funding, but what do you think about the political climate around all this?

Slough: I think we're under the radar right now, as regards to what we can demonstrate. So I think that we have, fortunately, from other fusion experiments that I've conducted in the past, a large amount of equipment that we can apply to this particular task. So that allows us to actually get much further along in this process. We were even thinking that we might be able to achieve breakeven, which is something that hasn't occurred yet in controlled nuclear fusion. Even with a simple experiment conducted by very few people, in this manner.

So, that part of it is fortunate for us, that we can achieve that. But obviously, future development, and particularly with the sophistication and the repeatability rating and all the other aspects of space travel, will require significant investment by NASA. But we hope we can interest the world with the fact that fusion isn't always 40 years away, and doesn't always cost $2 billion.