Click here for Full Issue of EIR Volume 14, Number 37, September 18, 1987

Toward a 'space agency' for all of Latin America

Space Shuttle Astronaut Franklin Chang Díaz describes his research in fusion propulsion, and his proposal for a Latin American space agency.

Dr. Franklin Chang Díaz, the first Hispanic American astronaut, flew on the Space Shuttle Columbia in January, 1986, the last mission before the Challenger explosion. He was born in Costa Rica on April 5, 1950. While in grade school, Chang Díaz wrote a letter to Wernher von Braun, asking him how to become an astronaut. Reportedly, von Braun suggested that he go to school to study science in the United States, and in 1967 he arrived here.

He received his Ph.D. in applied plasma physics from the Massachusetts Institute of Technology in 1977, and at the Charles Stark Draper Laboratory, began his research into fusion propulsion. Prior to his Shuttle flight, Chang Díaz toured Ibero-America, to encourage nations to establish a Latin American Space Agency, similar to the European Space Agency. In this interview with Marsha Freeman, conducted on July 20 at the third Case for Mars conference, Chang Díaz discusses both his own research, and his thoughts on bringing industrializing countries into the space age.

EIR: Could you describe the advanced fusion propulsion concept that you have been working on?

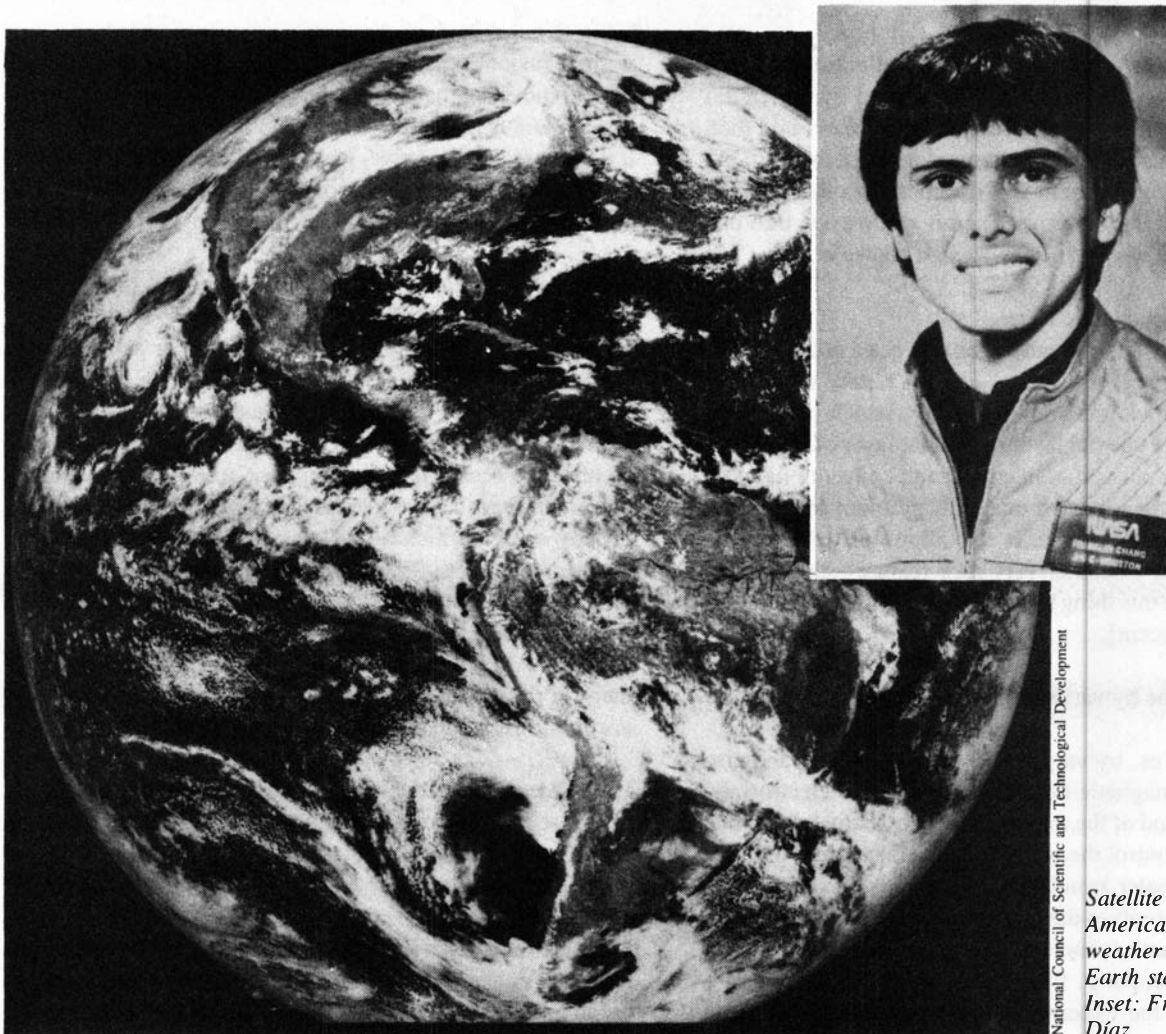
Chang Díaz: It's really not necessarily a fusion concept, at least not for now. We don't rely on fusion for it to work, but it is a high-temperature plasma rocket. The idea is, the higher the temperature of any exhaust of a rocket, the higher the efficiency of the rocket. That's what we in the rocket business call specific impulse. You can generate rocket thrust, either by throwing a lot of stuff out [the back end of the rocket] at low velocities, or very little stuff at higher velocities. Clearly the choice of approach is to throw a little stuff out at very high velocities, because that means that you don't have to carry as much [propellant] and so you have less of a fuel requirement. The problem is that if you double the exhaust velocity in a rocket, you quadruple the power required, because the power is proportional to the velocity squared. That's a very serious obstacle [now] because we don't have very high power sources in space yet. The other problem is that very high velocity exhaust means that the exhaust has to have a very high temperature, and very high temperatures mean severe materials problems on rocket engines, or nozzles, or anything like that.

The way we have attempted to deal with the materials problem and the power problem, is by going to the technology of fusion. In fusion, you deal with a plasma which is at a temperature of millions of degrees, but yet, this plasma is never physically in contact with the surfaces or the materials of the container, because you have a magnetic field and the plasma responds to the magnetic field, and stays confined. We have attempted to develop a magnetic nozzle [where magnetic fields would keep the super-hot plasma exhaust away from the material], not a conventional nozzle.

We are doing experiments up at MIT [Massachusetts Institue of Technology] on this sort of concept, and we call it a hybrid plume rocket. One of the attractive features of a plasma rocket like this, is that the exhaust velocity is no longer a constant [as it is when you are burning chemical fuels]. You can actually change it. You can have an exhaust velocity which is relatively slow, at first, and then increase it as the vehicle speeds up. That means that it has the potential to always be optimum. The best way to match the exhaust velocity to the actual rocket that you're using, is to always have the exhaust moving at the same speed as the vehicle. In that way, the exhaust particles leave the rocket with zero energy and they have given up all of their energy to the vehicle. That is the most efficient way to operate.

If you use that idea in a given mission, you save a lot of

© 1987 EIR News Service Inc. All Rights Reserved. Reproduction in whole or in part without permission strictly prohibited.



National Council of Scientific and Technological Development

Satellite photo of the Americas sent by GOES weather satellite to INPE Earth station in Brazil. Inset: Franklin Chang Díaz.

fuel. In a Mars mission, you even beat the most advanced electric propulsion concept so far, which is a magnetic plasma dynamic rocket. And it turns out that it is even better, as you go further and further out, because you're always operating at an optimum efficiency. The problems that we have, are the problems of fusion, namely the problems of keeping a plasma away from the walls of the container, the problem of sputtering [part of the plasma escapes to the container wall, losing energy], and the problem of radiation. We have a great deal of radiation losses in this plasma, and all of that radiation ends up in the wall[of the container], so we still have a little bit of a materials problem.

The other thing that happens that is very peculiar to a plasma rocket, is that when you have a plasma exhaust that is confined in a magnetic field, somehow you have to force that plasma to leave that magnetic field. Otherwise the plasma will curl around your rocket and come back and give you zero thrust. And so we have to find a way to detach the plasma when it leaves the rocket, and that's another serious problem. The hotter the plasma, the more it clings to the magnetic field, and the more difficult it is to detatch it. There are some schemes—two of them that we're looking at—one is injecting a coaxial layer of fairly high-density gas, which will create a lot of collisions in the plasma and make it diffusive and make it detach from the field. We also have other schemes whereby you can induce certain kinds of instabilities [in the plasma] right near the edge, which will allow the plasma to tear off from the field. They're far from proven—we don't know if these things are going to work or not—and that is basically the purpose of our experiment.

EIR: What kind of geometry do you see using for a fusion reactor that would be used for propulsion?

Chang Díaz: It would be a linear[as opposed to a closed, donut-shaped fusion] geometry. We will exploit the weakness of the mirror, which is that mirrors leak. [In our case,] we want them to leak. Our concept is a tandem mirror, which operates in an assymetric way. One end is more leaky than the other. We are trying to set up a condition where the plasma is actually flowing. The plasma will be injected at one end at low temperature. It will flow in to a central region, like the central cell of the tandem mirror, be heated by RF [radio frequency] power, at the ion-cyclotron frequency, and then we don't need a very high confinement time, because all we need is enough confinement to give energy to this flowing plasma, and then let it escape. Then it will escape into this exhaust, which is where this new design comes in. . . .

EIR: That's the magnetic nozzle?
Chang Díaz: Yes. The magnetic nozzle is a a nozzle which is initially a magnetic funnel, which then blends into a conventional nozzle with an annular ejector, which injects that very high velocity coaxial layer or annular layer of hypersonic gas. That combination of magnetic and conventional nozzle will allow us to solve the materials problem and also the plasma detachment problem. It also allows us to "tune" the exhaust, and that's another very nice feature—that we can basically throttle this thing [run the engine at different levels, less than 100 percent].

EIR: Is that done by varying the amount of gas put into the exhaust stream?
Chang Díaz: Yes, by varying the amount of gas, and also by varying the magnetic field strength, and the electrostatic potential at the end of the mirror. There are many "nobs" that one can use to control the mix of plasma that comes out. We have done computer simulations for about five years now, and everything points to the fact that you can actually do this. So far we have not encountered any show-stoppers. It looks, at least in the computer, [like it will work.] That is what is leading us into the experimental phase which is about to begin.

EIR: We don't have a machine that can produce the fusion for you yet. What kinds of experiments are you planning to do, to develop the technology?
Chang Díaz: We don't need to have fusion; all we need is a hot plasma. It doesn't have to fuse. In a rocket, the energy [to heat the plasma] would be coming out from an external power source, which could be a nuclear reactor, or some other kind of power source. Someday, when fusion is a reality, then we will be able to take away this external power source, and become a fusion reactor of our own.

EIR: You are saying, then, that the propulsion part of this design could be tested, and even operational in space before you have fusion?
Chang Díaz: That's exactly right, and that's what we're shooting for. That's why mirrors [fusion reactors, which have had technical difficulties] will be useful, because we're not [necessarily] expecting to create fusion in this configuration. All we want to have, is the hot plasma—hot on the order of maybe 800ev [electron volts] or 2 kev—that temperature range. The density could be a little higher than normal fusion experiments, but then we take a penalty on temperature, but that's fine. Our purpose right now is to build this apparatus in the lab, test it, and then perhaps very soon, if it proves to be attractive, we'll fly a prototype in the Shuttle. We'll try to deploy a [prototype plasma plume rocket] in orbit, and fire it and see how it works.

EIR: What would you use for a heat source, in an experiment that is deployed from the Shuttle?
Chang Díaz: Probably some sort of a power plant, such as the SP-100 [nuclear reactor under development by NASA, the Department of Defense, and the Department of Energy, which will be flight-tested in the early 1990s] or maybe even a cluster of fuel cells, anything that would give us enough power. It doesn't have to be steady state, it could be pulsed. So any source which could give us about 50 kilowatts of power, would be sufficient to test it. The point is that a lot of these experiments and machines need to be tested in the space environment. Some of the advanced rockets put out so much material [when you test fire them], it is very difficult to test them in a vacuum chamber [and have] the chamber keep a vacuum.

EIR: Almost all of the rockets we have ever developed, have been used to go from Earth to orbit, and have had to fly through the atmosphere. Your rocket would only be fired in space, so I could see why it has to be tested in the vacuum of space.
Chang Díaz: The vacuum is a problem, and the more power the rocket has, the more difficult for a vacuum chamber to maintain a vacuum. There are also other plasma physics considerations that need to be studied, such as the wake effects, plasma effects, electromagnetic effects, charging, and so on, in a vehicle that is completely detached from its environment . . . so we need to start doing experiments in space.

EIR: When the SP-100 is tested, the power from the reactor will be used, as I understand it, to test an electric propulsion system.
Chang Díaz: I think we need to start thinking about electric propulsion. The plasma rocket concept we are talking about is a form of electric propulsion; in the same sort of family of rockets. We need to start moving away from chemical rockets, because they just do not have the internal energy capability that a nuclear-plasma device can have. If we're serious about exploring the outer planets, in any kind of a reasonable time scale for crews to fly out there, we need to come up with a different propulsion system.

EIR: Any design you can come up with for chemical rockets, leaves you on a ballistic trajectory, or unpowered flight. Would the kind of system you are designing give you powered flight?

Chang Díaz: It turns out that the optimum tuning of the rocket gives you a constant acceleration, so for a constant power and constant acceleration, you have less and less thrust and higher and higher exhaust velocity. You start with a high thrust and low velocity, and end up with a low thrust and high velocity, by the time you get to your destination. It's a lot like a car. You start in first gear, and then you shift to second and third, and so on. It's very similar to that idea. If you can achieve an acceleration level which is fairly constant, that may even reduce the biological problems that we have to contend with in long voyages to the planets, where people are subject to zero gravity, so to speak. If we could have a ship that is always accelerating and, of course, decelerating at some point, then we might even reduce the biological problem.

EIR: Our view of this is that you are going to have to do that. It seems unlikely that you can subject people to 18 months of virtual zero gravity on a trip to Mars. The biological impact of long ballistic chemical missions is going to prohibit that kind of technology from being used.
Chang Díaz: I would agree with that. We need to find something else, not only to reduce the zero gravity problem, but also to shorten the trip time.

EIR: In the kind of system that you are developing, what would be the effect on a Mars mission? What kind of acceleration would you attain, and what would the trip time be?
Chang Díaz: We calculate that acceleration would be on the order of one-tenth of a [gravity] maybe a third of a *g*, depending on the power source. The trip time varies, depending also on the power source. You can get there in about two months or one and a half months, depending on the power source. A lot of the electric propulsion concepts will do that, and this one does it a little bit better. We can save a few weeks in a trip to Mars. If we are going out to the asteroids, we can save months over the best electric propulsion concept. So the further out we go, the more we save, the more attractive it looks. All of the electric propulsion concepts are attractive in this area.

EIR: For a ship going between a tenth and a third *g*, what would be the size of the power plant you would need for the propulsion system?
Chang Díaz: The one that we looked at, is a megawatt of electrical power, which is a lot now, but for the future it wouldn't be. It would be a vehicle with a payload weighing 20,000 pounds, and it will have an engine which would be about the size of an Orbital Maneuvering System engine on the Space Shuttle. The thrust levels could be as high as a couple of hundred pounds at first, and then as you speed up, you go to lower and lower thrust levels. It's far from optimized,[because] we are just trying to prove the physics of it first. Soon we'll sit down with all of our engineering expertise and really optimize it and come up with hard numbers on the power levels, [trip] time, thrust, and specific impulses, and so on. Right now, we need to just prove the concept.

EIR: What do you think of the work that Drs. Gerald Kulcinski and John Santarius are doing at the University of Wisconsin, using the tandem mirror fusion design with helium fuel, mined on the Moon? Creating fusion energy with deuterium and helium-3, as they are suggesting, would produce energy in charged particles, rather than in neutrons. Would this move into the more advanced fusion fuels that they are proposing, benefit your propulsion concept?
Chang Díaz: Oh yes, very much so. I think that's very [important] that they're looking at that area, because it's really the way to go. You want to not have anything tied up into neutrons, because the only way you can extract their energy is by a thermodynamic process [extracting heat], which always tied you to a thermodynamic efficiency and lots of heat losses. If you can do everything with charged particles, then you can have a direct conversion possibility and also much higher efficiencies. That would be absolutely great.

Science on the Shuttle

EIR: What are your plans in the Shuttle program?
Chang Díaz: I look forward to flying many times—as many times as my body will take. I hope to be on the space station. One of the things that I have been pushing for within the astronaut corps, is to make the astronauts more active participants in the science and technology that's being carried out on the Shuttle. In the past, there has been a little bit of a separation between the astronaut and the scientist. A lot of the payloads that we flew in space had only one switch—essentially an on-off switch. If you threw the switch and it worked, it's fine, but if it didn't work, then you could not do very much about it. That to me is a very inefficient way of doing science. It's also a little bit of an insult to the scientific capability of the people in the program. I think that the way to do science is interactively. Put the human in the loop and let the human make decisions right there. We have been going into this idea of robotics and automation, and I am opposed to a lot of that because I believe that we cannot automate things that we do not understand yet. Perhaps when we understand them, then we can automate them, but right now we don't.

The other thing is that we need to have people who are able to understand the Shuttle, and the space station, because the Shuttle and the space station are vehicles which are part of the instrumentation that you use to do your experiment. We cannot send a scientist up there to do an experiment and not have that scientist trained and understand what the vehicle that he's flying on, is doing. That's a deficiency that needs to be corrected.

EIR: The Shuttle is the first space program where the commitment was made that scientists would fly. How much opportunity do you think there will be for scientists to go into space to conduct their experiments, or for their experiments to go into space, even if they can't?

Chang Díaz: I think that at first in the Shuttle, and in the early phases of the space station, the scientist-astronaut has to be a generalist. He has to be able to do many kinds of experiments in many areas, and do them well. He has to understand the operating constraints and the operating regimes of the vehicle, that make that science possible. We probably should not be thinking about very specialized individuals, but more like generalists. People who understand the basic nature of the experiments that are being carried out and can interact with the principal investigator, the scientist who has spent all of his or her life doing this experiment.

We have created a new group called the science support group, and our task is to interact with the scientists who are designing experiments to fly, early on, before those experiments have been completely delineated or designed. We will try to transmit as much as we can in the way of operational expertise. We have gathered a tremendous amount of experience in 25 Shuttle flights, we know how to do things, how they work and they don't work, we know experiments that are going to make sense, can be repaired and accessed, and we know how not to design experiments. A lot of the time that expertise has not been transferred, so the same mistakes are made over and over again.

We are trying to correct that problem. The most interesting science happens right there and sometimes you don't even expect it. You just happen to look at something at the right time, and it behaves a little differently than what you thought, and if your experiment does not have the flexibility, you cannot catch it. But if your experiment has flexibility, and the astronaut can interact, then you get the data point. That's the smart way to do things, not a black box with an on-off switch.

EIR: This group of astronauts will then be working with the scientists from the beginning, before they've set up their experiments?

Chang Díaz: That's right. We have also set up a new program within the astronaut office, called the science colloquium program, and each month we bring scientists from the [scientific] community in to interact with us. We are studying space tethers, remote sensing, materials processing, plasma physics—a whole realm of different things. We're trying to set up the astronaut office and corps as a very credible, very capable group of scientists who are also astronauts.

EIR: Do you know how many people in the astronaut corps are scientists?

Chang Díaz: It depends. "Scientist" is a very loose term. Some people are engineers, and some of the scientists that became scientists, did their work in engineering, like me. I'm an engineer. That's really my background—mechanical engineering. A lot of the technology tests and development that we are going to be doing in space requires engineers, people who are well-versed in EVA [extravehicular activity, or space walks] techniques and understand the laws of physics very well. That's what the mission specialists are all about. The mission specialist is more the jack-of-all-trades. Some of us have Ph.D.s and have gone deeper into certain scientific areas, but are perfectly capable of doing other things, and we are trying to diversify. I'd say about 20-30% of our office falls into that category. People in our office are very operationally oriented. They want things to work. They don't want a system that is limited from the time it takes off from the ground. They want a system that can be reconfigured and changed. If we are going to fly a radar to do synthetic apertures for remote sensing, we want to be able to point it ourselves, not to have a ground command send it to move in some unknown direction.

EIR: You mentioned before that the vehicle you're flying in is part of the instrumentation of your experiment.

Chang Díaz: Yes, that was very evident in the Spacelab 2 mission to study the behavior of the Shuttle and the environment of the ionosphere that the Shuttle flies in. The Shuttle deployed a small plasma diagnostics package which was allowed to free-fly away from the orbiter, and the idea was to study the wake effects [electromagnetic interaction of the orbiter with the Earth's magnetic field and environment]. To do that the Shuttle was flown in a very intricate set of maneuvers around this package to create different kinds of wakes. You have to understand how this wake was forming and what it was that the package was trying to measure. If you understood that, then you could fly the Shuttle to do it best. There were some instances in which we had to fly the Shuttle away from the plane of the orbit to set up a flux connection between the Earth's magnetic field and the field lines from the Shuttle to the plasma package and then launch Alfven waves along the direction of the field, so you have to fly at just the right altitude, and rate. You've got to understand the platform, the vehicle, and its operating capabilities, at the same time that you understand the science. We have not done that with the scientists that had flown in the past. Either they were scientists who just concentrated on their experiment and were not trained on the Shuttle, or vice versa. We need to merge the two together.

EIR: How will the space station open up new capabilities for science and technology?

Change Díaz: If we do it right, and we do the homework that needs to be done in the Shuttle, then when the space station comes along, we will have the expertise to have a well-integrated marriage between the operations and the science. Or call it operational science—a team of people who can best do the experiments.

search facilities today, you don't see a single scientist working off all by himself or by herself in a little project. You see teams of people working together. That's what we need to do—operational science. It requires a whole spectrum of people not just scientists, or just technicians.

EIR: I guess you'll get a chance to go to work on the space station?
Chang Díaz: I hope so.

A space agency for Latin America

EIR: You did an interview with the Spanish language *Fusión* magazine a while ago, when you were on a tour of Latin America. In that interview, you expressed your ideas on the importance of getting the developing countries involved in the space program, and space technologies. What are your thoughts on that now?
Chang Díaz: It's like what's going on in Europe. Europe has an organization, the European Space Agency (ESA), which represents the European Community in this space adventure. Other communities, like the Southeast Asian countries, also are gathering their resources to form their own ASEAN community for the same purpose. I think of the developing areas of the world, only Latin America and Africa are areas that don't have bodies that would represent them in the space arena. Therefore, only very large powerful or semi-powerful countries like Brazil and Argentina can get involved, [but only] to a very limited extent, because even they cannot really compete in their budgets.

So one of the things that I have been trying to push for, is the creation of a Latin American Space Agency, which would be a working body, very similar to ESA, to bring Latin America to the forefront of space technology and the benefits from it. I talked during my tour of Latin America about remote sensing as one of the most important things they can benefit from right away. Communications also. You know that the communications satellites are geostationary, and have to be in equatorial orbit. Because geostationary orbit is unique,[22,300 miles above the Earth], there is only a limited number of satellites in space. When those countries are able to put their own satellites up there, there will be no room left for them. So all of these issues need to be resolved in an international forum, and they need to be looked at in a serious way. In the end, I think that when we move out from the Earth and we are all citizens of the Earth, we will not really be citizens of any given country. It would make sense that we start coming together, before we do that.

EIR: NASA is developing new applications of remote sensing technology, such as tracking the migration of disease-carrying insects, which could be extremely valuable for countries in Latin America. What do you think the potential benefits could be to nations in Latin America, from this kind of technology?
Chang Díaz: I think the benefit for Latin America would be to be able to develop very, very quickly. It would be able to take a short-cut in development and get to the end of the 20th century, without having to go through all of the complicated developing processes that the developed nations went through. That would be one thing. The other thing that happens, is that when a country develops, it becomes a consumer of high technology, and a country like the U.S. could be a very big supplier to countries which are suddenly consumers of high technology. There is a symbiotic relationship that right now is not being exploited.

A country that does not have high technology, depends on the U.S. via foreign aid, and the U.S. has to come up with money to give those countries so they can survive. But if they were developed, they would be able to pay for their own technology with their own money, and they would live better, and it would be better for the U.S., as well. All I'm saying, is that it makes sense to develop, and develop technology in those countries. I think that the basic problem in Latin America is a tremendous inefficiency in land usage, resources, communications. It would improve everything so drastically, if we could just communicate, if we could do it in an efficient way; if we could tell the people at the shores where the schools of fish are, so they could go fish there.

If we could tell the farmer when the floods are coming, or what [the cyclical storm system] "El Niño" is doing, it would be incredible. In Mexico, one of the biggest problems is that a farmer of potatoes, for example, grows a bunch of potatoes, but he doesn't know where the market is, or where to go to sell them. One way to do it is to communicate via satellite, and find out where the potatoes are needed. These are problems that affect all developing nations, and they could be solved.

EIR: Should there be an effort made to involve these countries more directly in the U.S. program, such as the guest astronaut program?
Chang Díaz: If that really involves people. There is a difference between public relations and real honest to God collaboration. I think we need to move towards a more realistic collaborative program. I think, for example, by having a body that could oversee this sort of participation we could ensure, like the countries in Europe, that they are actually participating in space, and not just being awed by it or being perhaps taken along to see this or that, but actually be real participants in the technology. You have to be careful as to how this gets done.

EIR: It would likely make more sense to have 100 people come up here to be trained using the technology. . . .
Chang Díaz: Exactly. That, to me, would be crucial. If we could use some of the [NASA] tracking stations [used to communicate with the Shuttle and satellites] that we don't need anymore, such as the tracking station in Chile, or in Equador that we used for the Shuttle, if we could train people from those countries to use those stations to interact with Landsat or the [French remote sensing] SPOT satellite or whatever, then we are doing something good.