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The Brandenburg 300 Project

Update: Voyager 2 leaves our solar system on November 5, 2018, It was 11.1 billion miles from earth. Voyager 1, which crossed into interstellar space on August 25, 2012, is 13.4 billion miles from earth. Voyager 2 was launched on August 20,1977, and Voyager 1 on September 5, 1977. They travel around 290 million miles per year.

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Honors

The Voyager Project

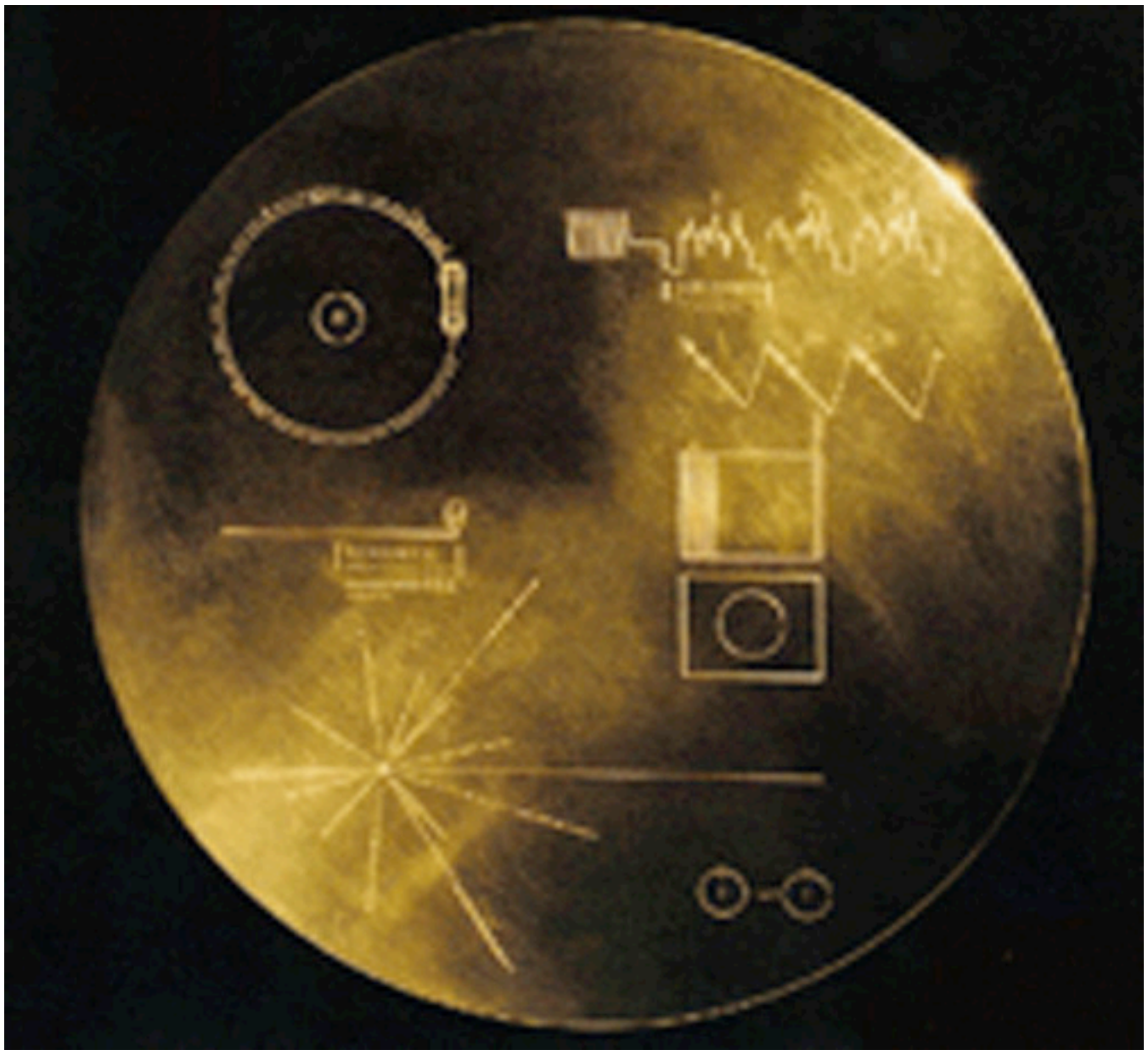
Jet Propulsion Lab's Voyager Site
http://voyager.jpl.nasa.gov

Note: Brandenburg 21 Voyager and Brandenburg 62-1 Voyager 2 are both honored by the Brandenburg 300 Project, and the material below is for both recordings.

Also, below the Voyager material, there are excerpts of my time at JPL in the late 1970's taken from the book, *"A Funny Thing Happened on the Way to Energy Independence*."

The Voyager spacecraft was launched in 1977 and carries on its side a gold record that is humankinds first “time capsule” sent in hopes of encountering and communicating with civilizations on planets other than our own. It embodies the hopes and dreams of the people of our planet, and offers the beauty of its music and art as examples of the best of who we are. The first music on the Golden Record is the Brandenburg Concerto - making it arguably

the most important single piece of music ever recorded, and certainly a standard by which all other music can be judged. The version selected was performed by Karl Richter and the Munich Bach Orchestra.



Link to "Brandenburg 621 Art Space Music"

From the JPL Voyager project Website

(June 2013)

The twin Voyager 1 and 2 spacecraft continue exploring where nothing from Earth has flown before. In the 36th year after their

1977 launches, they each are much farther away from Earth and the Sun than Pluto. Voyager 1 and 2 are now in the "Heliosheath" - the outermost layer of the heliosphere where the solar wind is slowed by the pressure of interstellar gas. Both spacecraft are still sending scientific information about their surroundings through the Deep Space Network (DSN).

The primary mission was the exploration of Jupiter and Saturn. After making a string of discoveries there -- such as active volcanoes on Jupiter's moon Io and intricacies of Saturn's rings -- the mission was extended. Voyager 2 went on to explore Uranus and Neptune, and is still the only spacecraft to have visited those outer planets. The adventurers' current mission, the Voyager Interstellar Mission (VIM), will explore the outermost edge of the Sun's domain. And beyond.

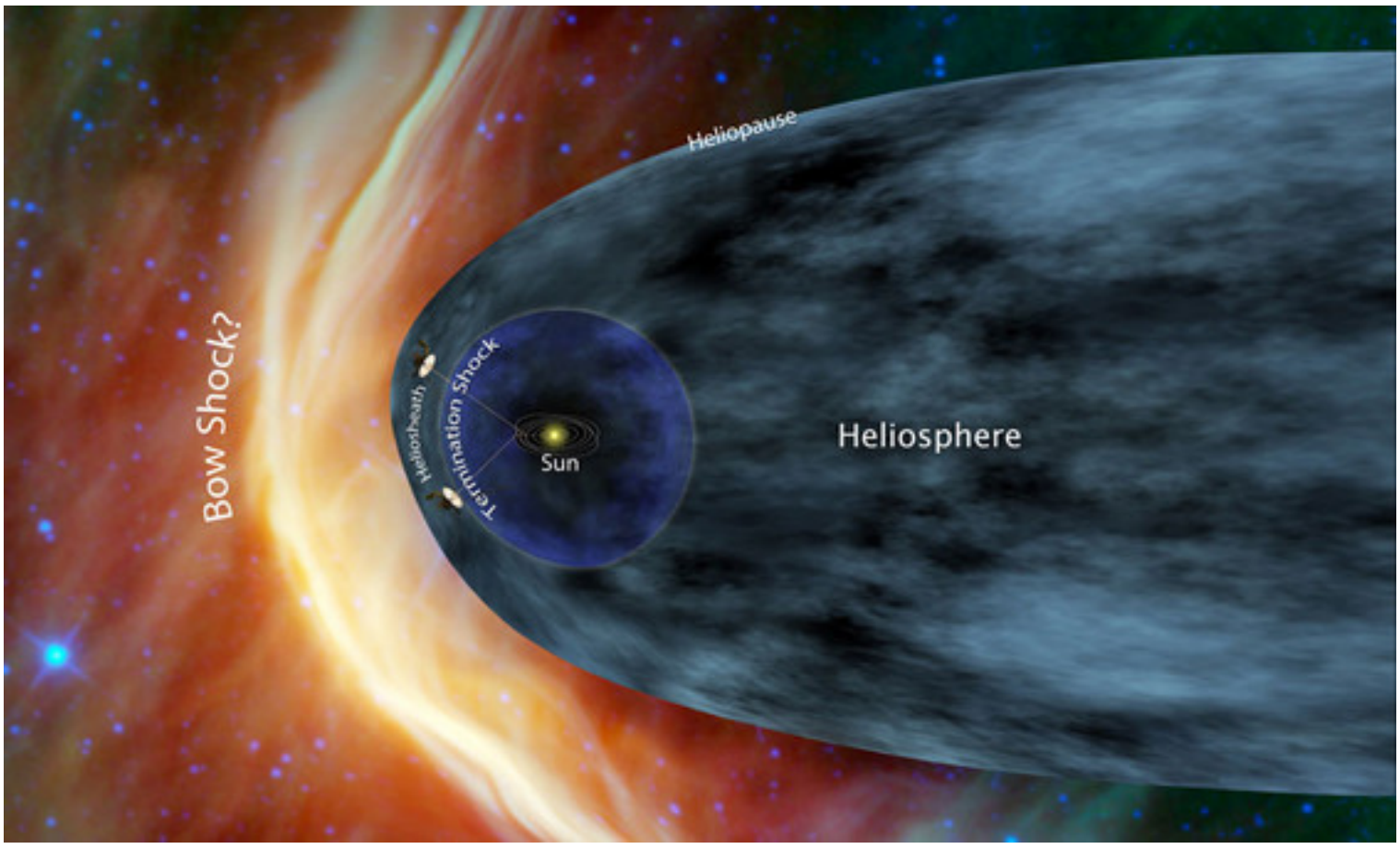
Golden Record

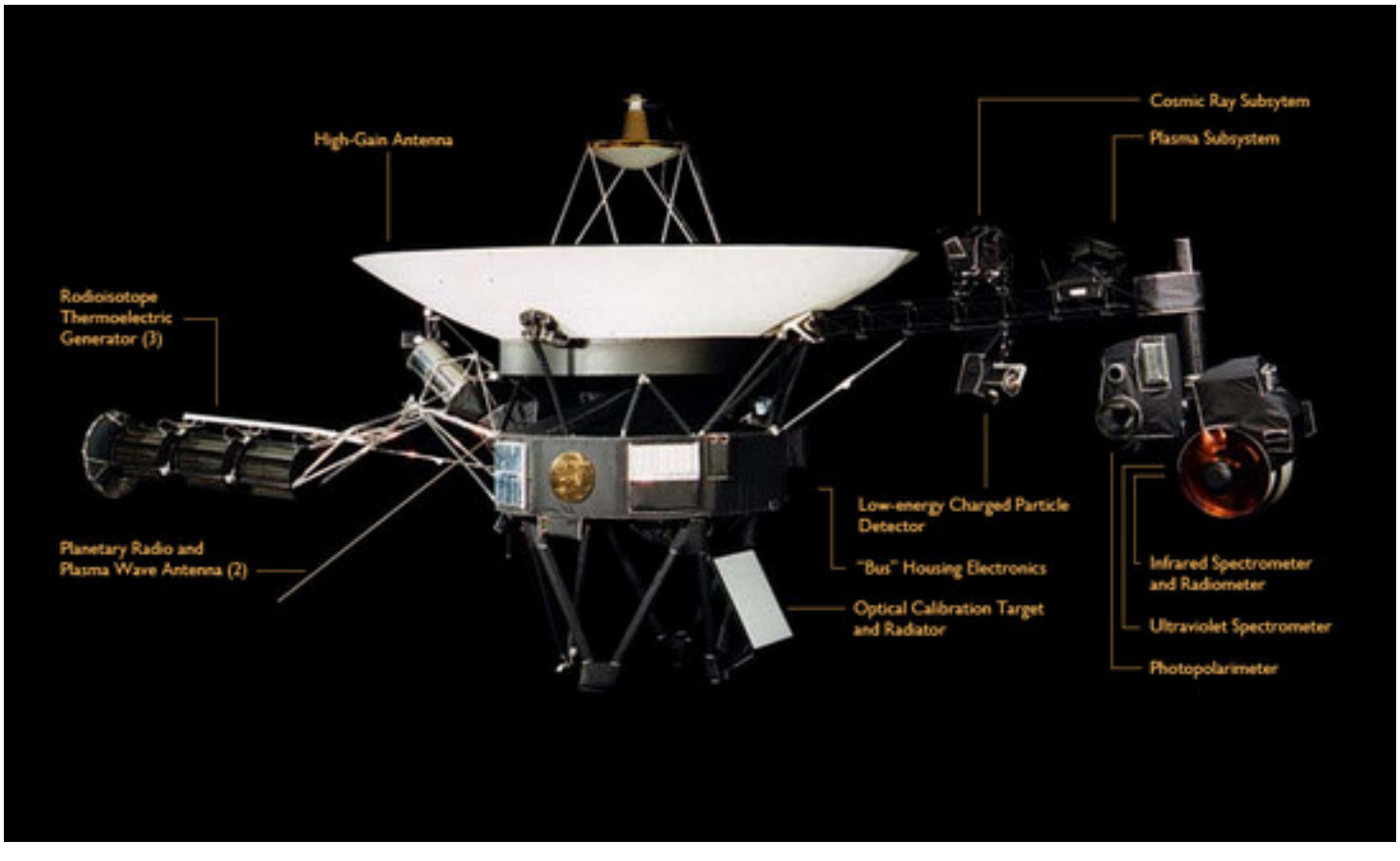
Pioneers 10 and 11, which preceded Voyager, both carried small metal plaques identifying their time and place of origin for the benefit of any other spacefarers that might find them in the distant future. With this example before them, NASA placed a more ambitious message aboard Voyager 1 and 2-a kind of time capsule, intended to communicate a story of our world to extraterrestrials. The Voyager message is carried by a phonograph record-a 12-inch gold-plated copper disk containing sounds and images selected to portray the diversity of life and culture on Earth.

The contents of the record were selected for NASA by a committee chaired by Carl Sagan of Cornell University, et. al. Dr. Sagan and his associates assembled 115 images and a variety of natural sounds, such as those made by surf, wind and thunder, birds, whales, and other animals. To this they added musical selections from different cultures and eras, and spoken greetings from Earth-people in fifty-five languages, and printed messages from President Carter and U.N. Secretary General Waldheim. Each record is encased in a protective aluminum jacket, together with a cartridge and a needle. Instructions, in symbolic language, explain the origin of the spacecraft and indicate how the record is to be played. The 115 images are encoded in analog form. The remainder of the record is in audio, designed to be played at 16-2/3 revolutions per minute. It contains the spoken greetings, beginning with Akkadian, which was spoken in Sumer about six thousand years ago, and ending with Wu, a modern Chinese dialect. Following the section on the sounds of Earth, there is an eclectic 90-minute selection of music, including both Eastern and Western classics and a variety of ethnic music. Once the Voyager spacecraft leave the solar system (by 1990, both will be beyond the orbit of Pluto), they will find themselves in empty space. It will be forty thousand years before they make a close approach to any other planetary system. As Carl Sagan has noted, "The spacecraft will be encountered and the record played only if there are advanced spacefaring civilizations in interstellar space. But the launching of this bottle into the cosmic ocean says something very hopeful about life on this planet.

The definitive work about the Voyager record is "Murmurs of

Earth" by Executive Director, Carl Sagan, Technical Director, Frank Drake, Creative Director, Ann Druyan, Producer, Timothy Ferris, Designer, Jon Lomberg, and Greetings Organizer, Linda Salzman. Basically, this book is the story behind the creation of the record, and includes a full list of everything on the record.





Excerpt from A Funny Thing Happened on the Way to Energy Independence

by Robert Danziger

Chapter 2

JPL and Caltech Days

After graduating from law school, my professional career began at Jet Propulsion Laboratory (JPL) in Pasadena. Home of the U.S. deep space exploration program, JPL was called upon to work its magic leading the alternative energy programs essential to winning the "moral equivalent of war" due to oil embargos and the deep recessions that followed.

The California Institute of Technology, popularly known as Caltech, is the "academic home" of Jet Propulsion Laboratory and runs it as a national laboratory, mostly for NASA. Caltech is one of the elite universities, like Stanford, MIT, and Harvard. It has a small enrollment of fewer than one thousand students and about the same number of teachers.

Einstein taught there, as did Linus Pauling, Richard Feynman, and Murray Gell-Mann. Nobel Prize winners get special parking places.

JPL has about six thousand employees, primarily space scientists and engineers, and it's the place that managed the exploration of our solar system for the United States. Starting with the moon, JPL has sent satellites to all the planets, unless you include Pluto, which was demoted to a space rock and is no longer considered a planet.

JPL has taken incredible pictures and made amazing sound recordings of Mars, Jupiter, Saturn, Uranus, Neptune, Venus, Mercury, the sun, and now interstellar space.

Just a few years earlier (1970), the greatest environmental

movement in history started when more than 90 percent of ALL the people in the United States ranked clean air and water in their top three political concerns after *Apollo 8* took this picture:

The view of the earth from the moon brought home the fragility of the planet to people in ways that scientific studies and political rhetoric have never equaled. It was a shining moment of bipartisanship I've never seen again but still believe in.

Then, in the mid-1970s, a confluence of several events heightened the world's awareness of energy and environment to levels never seen since. OPEC, after the 1973 Arab-Israeli War, started choking off oil supplies to the United States. Actual gasoline shortages resulted in long lines of cars waiting to buy rationed gas. Oil prices skyrocketed, causing a severe recession combined with sky-high interest rates.

President Carter called the situation the "moral equivalent of war." Seemingly impossible things needed to be achieved for victory in this war—energy independence and a clean environment coupled with prosperity. Solar energy had to be reduced in cost by 99 percent (by 2009, we were 94 percent of the way there) to compete with fossil fuels. A mass-producible electric and hybrid car had to be invented. Natural gas had to be produced from rocks like coal and shale. Giant windmills needed to sprout like cornfields. A thousand other ideas had to be examined, often tried, and then decisions had to be made about their future.

JPL, at that time, had never failed at accomplishing the impossible. Fly to the moon? Fly to Jupiter? Saturn? All done to perfection. Incredibly difficult scientific and engineering systems had to be invented, on a schedule, and had to work under the watchful eye of the people on earth. And JPL had never failed, unlike the other national labs, which had experienced a more normal failure rate.

With this national energy crisis, JPL was called upon to work its

magic in interplanetary space exploration on the energy and environment problems of earth. JPL responded by undertaking lead responsibility for solar energy and the electric and hybrid vehicle, and was deeply involved in alternative fuels, underwater nuclear power plants, solar-powered satellites that could beam energy back to earth, and everything in between.

Like many, I dove into this national emergency, and suddenly found myself among JPL's mix of academic and scientific elite who were trying to solve these problems. I had no undergraduate education, let alone a degree, and the highlight from my law school education was a professor giving me a B and commenting:

> **"That's the highest grade I've ever given to anyone who didn't actually attend my class."**

Nevertheless, it was the perfect start for a young kid just out of school to pursue the impossible dream of prosperity coupled with energy independence and a clean environment. JPL expected to achieve the impossible, and that suited me perfectly.

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JPL had put together a systems analysis section, to support the scientific and engineering work and to meet the nation's need for policy formulation and analysis. More common today, systems analysis was in its middle childhood at the time.

Systems analysis involves a Noah's ark of professionals, all looking at a challenge from each of their unique perspectives: architects, operations researchers, environmental engineers, economists (lots of economists), lawyers, biologists, anthropologists, geographers—all kinds of people in the same boat.

When systems analysis works right, all these professionals are

rowing in the same direction. When it doesn't work right, as my mom observed, "The smartest people do the dumbest things." That's how I know I'm a genius.

Chapter 3

My Weird Education and Career Prep

A look of horror spread across the face of my wife's friend, a professor at Stanford, as I described my checkered, out-of-the-box educational history to her. Although, to be fair to myself, I actually am infinitely curious, love to learn, and spent my time away from law classes studying engineering, physics, and a bunch of other things while working two jobs—as a data processing manager and as a musician playing in recording sessions.

The weirdest thing about my education is that, even though I went to law school, passed the bar, developed and taught alternative energy law, worked for and lectured at Jet Propulsion Laboratory and Stanford, I went to undergraduate school for only three months and then became a professional musician. After barely making a living as a musician, I took and passed the college equivalency exam and got into law school.

I first tried Mid-Valley College of Law—the "best law school on Van Nuys Boulevard"—a school distinguished by the fact that not one of its students ever passed the bar exam. I eventually transferred to a real law school, Whittier Law School, which

wasn't as funny.

And, as the professor who gave me the B noted, I didn't exactly go when I went, if you know what I mean. I would stay just long enough to be counted for attendance purposes and then get out of there as fast as possible.

What did get my complete focus was an alternative energy device I had invented just a few months before starting law school. It used solar, wind, and biomass energy to supply all the electricity a home needed, with some left over. I was very curious, since I was in law school anyway, about what laws and regulations my invention might encounter.

My invention featured a windmill and solar system that both produced heat. The heat went into a storage tank that also used a burner for natural gas and biomass (i.e. "bathroom burps") generated around the home. All this stuff was incorporated into a prefabricated garage. Although, as it turned out, not commercially practical because of the size of the heat storage required, it was a great platform for learning about energy because it had more or less every technology and energy product

folded in. Fortunately, the legal and regulatory implications of the device extended into the areas that became the big issues of the next decade.

I was given the freedom at law school to concentrate on and write about alternative energy law, and this was before any such class existed anywhere in the world. As a result, I was one of the first students to study and then teach alternative energy law.

My thanks to Dean Friesen, who declared:

> **"When someone is describing the nature of the universe to you,**

unless they are floating six inches above the ground it's just an opinion."

And later:

"When two men are discussing the universe, the one thing you can be sure of is that theirs is bigger than yours."

I can't tell you how often those thoughts came in handy… especially when things did not go as expected.

Chapter 4

JPL: Getting the Job

For the first National Renewable Energy Technology Conference, held in Tucson, Arizona, I submitted two papers on solar energy and both were accepted. I had recently graduated from law school and was looking for a job.

When I received the program for the conference, I called the other presenters and tried to subtly sound them out about recommending possible employers. With their recommendations, I interviewed at TRW and Fairchild Semiconductor, both of which were doing early work in solar energy under various federal programs.

One conference speaker was from Jet Propulsion Laboratory. He told me JPL didn't use the normal interview process. Rather, prospective employees were first invited to give a seminar, and if that went well, they were invited back to do a more standard interview. A seminar was organized, and I got paid a couple hundred dollars as well! That was big money for me then.

But first, I needed a topic for my seminar.

As a follow-up to my law review articles and the speeches at the conference, I wondered what would happen if trying to build a gigantic solar energy system. Sort of a giant version of my invention. Such giant solar and wind systems are common around the world now, but none existed back then. What legal problems would they face? How would they finance it? Did different technologies raise different legal issues? Did size matter?

I had recently given a lecture at the University of California, Los Angeles (UCLA) Engineering School based on this study of the legal implications of large solar energy systems making and selling electricity. I decided to title my seminar at JPL "The Legal Implications of a One Megawatt (Five Million Dollar) Solar Power Plant." Unbeknownst to me, JPL had just gotten a contract from Congress to write a report on "The Legal Implications of a One Megawatt Solar Power Plant."

Same name, same subject matter. Sometimes you just seriously luck out. The dream was steaming down the track.

Chapter 5

Give or Take $500 Million

JPL was the lead center in the United States for alternative energy in the late 1970s and early 1980s. One of JPL's responsibilities was to recommend a budget for solar electricity research for the coming year. I was one of the junior staff people on the effort, and we worked day and night for several weeks to prepare three options for the government to consider.

If I remember correctly, the "low" scenario was two billion dollars or so, the "medium" was four and a half billion dollars, and the "aggressive" scenario was seven or eight billion dollars. A Saturday conference call was arranged with the chief of staff for the congressional committee, Henry Eaton, to brief him on our conclusions.

On some of my earlier trips for JPL to Washington, DC, I had gotten to know Henry. We had a few meals together, and he'd helped us out on a bizarre problem we had with the Department of Energy. Congress had allocated ninety-eight million dollars to put solar electric systems on federal buildings. For political reasons too strange to recount here, the Department of Energy had decided to use the money to put solar-powered fans on outhouses in the middle of national forests.

I'll stop for a moment while you think about that one.

We were in the middle of a national energy crisis and the Department of Energy wanted to put almost one hundred million dollars into outhouse fans?! Henry got the department to change course and install the solar systems in places where they were really needed, which you've probably seen, around remote towers, gates, and harbors.

Anyway, we were all standing around the conference table, senior

JPL people briefing congressional staff and leaders, and we junior-staff types getting documents, preparing numbers, and so on. They had been going at it for an hour or so, and the Washington folks focused on the four-and-a-half-billion-dollar program. In the middle of all this, Henry asked,

"Is Bob Danziger there?"

"Yes, I'm here, Henry."

"Bob, is the four-point-five-billion-dollar scenario right? Are the numbers right?"

"Yes, Henry, give or take five hundred million."

"OK, Bob."

And that's what went to Congress.

About an hour later it hit me: give or take five hundred million! I was making $19,500 a year at the time. Give or take five hundred million?

Chapter 6

A law was passed in 1978 that changed the course of energy history. This law was the focus of that first JPL seminar about the legal implications of big solar energy power plants. Until this law was passed, only public utilities and governments could own power plants in virtually the whole world. Solar energy, wind energy, and energy conservation were not of much interest to them, and many viewed all this alternative energy stuff as a threat. The law was on their side, so they could stop it.

JPL took a keen interest in the new law, which was called the Public Utility Regulatory Policies Act, or PURPA, and I was authorized to write a book about the law and the regulations because of their potential impact on solar technology and other technologies JPL was working on.

The next thirty years proved that the predicted impacts of PURPA largely occurred as expected—enough alternative energy has been installed worldwide to equal one whole United States' worth of electricity production. And almost every one of those companies that opposed alternative energy now supports it.

SWEL and the Beautiful Blonde

When this energy law was passed, making it legal for companies and individuals to own their own solar, wind, and other alternative energy power plants, the regulations and guidelines for implementing it were put together by the Federal Energy Regulatory Commission (FERC). FERC is a powerful federal agency little known to the public, but its influence in our daily lives is felt every day—unless you don't use electricity or gas. You could say we get FERC'ed every day.

As part of the process of implementing the law, hearings were held in a handful of cities around the country, and they were dull. Incredibly dull. If you think your life is dull, try ten days of parsing public utility law; it'll make you want to be a proofreader for the white pages of the phone book.

The big hearing, though, the one where the big guns came out, was in Washington, DC, in the old FERC offices near DC's Union Train Station, right down the block from the Capitol. The hearings in Washington were scheduled for three mind-numbing days and promised to be a steady drone of lobbyists and delusions of grandeur. The staff actually had been fun, but the speakers had been snoozers.

And then in walked a gentleman, probably in his late sixties, wearing a white suit, white shoes, white fedora, red silk tie, and gold nugget cuff links. He was rocking an ebony cane with a carved ivory handle and gold inlay. On his arm was a drop-dead gorgeous blonde, probably twenty-eight years old, also dressed in white—white silk dress five inches above the knee, four-inch spike heels, seamed white fishnets, a pin overflowing with white pearls, sparkling diamonds, sapphires, and a large ruby implying a flower. Her wedding ring, in a traditional setting, had a rock the size of a cherry.

They registered to speak and found a spot in the corner to begin the three-day wait. He was one of the last speakers. In the meantime, they'd stroll around the room, he leaning on the cane, and she holding his arm so that her "ampleness" was well framed. We had two choices: we could focus on the speakers—"Section 201 is silent on the propitious opportunity of blah-blah-blah"—or we could look at them, and by them I mean her.

Each day the mystery deepened. Who was he? Who were they? Where were they from? How did that old guy get that girl? They weren't discourteous; we knew they had Southern accents. They nevertheless did not engage in much conversation with the rest of

the audience

Finally, after maybe a hundred speakers, he was called upon to make his statement. From the witness chair, he said he was representing SWEL Electricity. That's right, SWEL, the same things our hearts and minds did when we saw that girl.

SWEL, it turned out, was a program started by Oglethorpe Rural Electric Cooperative, the largest in the country, to use the poop from cows, pigs, and other farm animals to make electricity. The idea was that if it took the manure from fifty cows or the pig pies from 120 pigs to power a farm or something, the farmers in the cooperative would each locate that number of animals at a central location, where the manure would be collected and processed into electricity. He wanted to make sure the law didn't prevent that kind of thing.

At the end of his testimony, a commissioner said that he understood the man's concerns, but had a question:

"What does *SWEL* stand for?"

"You take the first two letters of swine, *SW*, and the first two letters of electricity, *EL*, and that's what you get: *SWEL*—Swine Electricity."

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These were the hearings that launched the largest alternative energy, environmental, and economic happening ever in energy, and all it took was a beautiful blonde and a whole bunch of pigs.

Chapter 7

Putting the “Rock” Back in Rocket

Oil isn’t always oil. Sometimes it’s something like oil that is squeezed out of sand or shale rock or coal. In fact, there’s far more of the part of oil that we use (hydrocarbons) in these other things than there is in oil itself.

These gooey or rock-hard types of oil need a lot of water and they pollute, just like oil. Many of us were and are researching ways of bringing up the good stuff, while leaving the bad stuff like greenhouse gases and smog makers deep in the earth. Many of these underground energy conversion systems require very large tunnels to process the rock and collect the oil.

JPL had a program to fund pet projects of scientists and engineers. A JPL engineer came in to present his idea for building gigantic tunnels to our team, which was evaluating grant requests. He noted that big rockets are the same size as train tunnels—the perfect size for large-scale recovery of these oil substitutes. He got the bright idea to build a rocket that went down instead of up.

He excitedly exclaimed:

> **“What is the earth? It is just *thick space*!”**

He was very animated, which is always funny for a guy with pocket protectors and a long-ignored hairdo. But the thick space in this case was between the ears.

He also had the idea of building a tunnel from New York to Los Angeles, two hundred miles beneath the surface (now that's an escalator!), that would have had these trains capable of traveling from coast to coast in half an hour. When I asked him how it worked, he said, "It spends most of the time slowing down."

Chapter 8

Doctors Jump Out of Cakes Too

Congress and the country wanted to know then, just like today: how cheap does solar energy need to be to compete with fossil fuels? It might seem like a simple question, but there were so many things we didn't know that computer models were needed to figure out what the questions were, let alone give us answers. No models existed, so JPL needed to make them.

JPL had dozens of PhD economists, operations researchers, analysts, computer programmers, engineers, and scientists working on this problem.

Twenty of us were sitting around waiting for a conference call. A secretary popped her head in and said there was a call for Dr. Brun. He assumed it was the call we were waiting for and put it on the loudspeaker. The caller asked:

"Is this Dr. Brun?"

“Yes.”

“Were you an engineering professor at UCLA?”

This was a strange question. We were expecting a call from a colleague in Washington to talk about some administrative stuff.

“Yes.”

“Well, I’m Bill Watson and I’m the CEO of an advertising company in San Francisco. This might sound funny, but… next week is Secretary’s Day, and the secretaries were looking through old copies of *Playgirl* magazine and voted you the man they most wanted to see jump out of a cake. Doctor, do you jump out of cakes?”

Twenty pairs of eyes turned slowly to Dr. Brun.

It turned out that, in addition to holding two PhDs and an MBA, he had been a centerfold in *Playgirl*. Some guys. As a friend once said, “It’s not a talent pool; it’s a talent puddle.” Dr. Brun was in the puddle.

You might be interested to know that the financial model that came out of this work was the foundation for thousands of models which came later and resulted in hundreds of billions of dollars invested in alternative energy.

Chapter 9

Teaching: JPL Outreach

JPL encouraged its employees to teach and allowed flexibility in work hours to accommodate the many people at the lab who taught at local schools.

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Corona-Norco State Prison

I was teaching at a few places, including Corona-Norco State Prison, a medium-security prison east of Los Angeles that had a program to train the inmates to install solar energy systems. During the two-year program, they would learn the skills and get some experience so they hopefully could land a good-paying job when they got out.

Corona-Norco Prison was built after WWII from a military base given to the state by the army. The land and buildings had been owned by an Italian millionaire before the army commandeered them for the war effort. The millionaire's mansion had become the headquarters and cafeteria for the prison. The prison cafeteria was in a room that featured forty-foot painted ceilings and a fortune in grillwork.

The mansion also had a gold-plated swimming pool. *Corona-Norco Prison had, for real, a gold-plated swimming pool.*

The students in the solar installer class were a colorful group. To enter the program, an inmate needed to have at least two years left on his sentence, so none of the guys were choir boys. For example, I was showing a picture of long lines of cars waiting for gasoline during the 1973 Arab oil embargo, and one of the swarthier inmates asked me to stop. He walked over to the picture, pointed at a freeway underpass, and said, "That's where I used to buy my coke."

And when I mentioned that, as installers, they had to be careful what promises they made to the homeowner because their employer could be liable for these, he said:

> **"I can say whatever I want; they'll never prove it."**

You could see why this guy was in prison.

Another fellow was clearly smarter than all the other guys. I asked him where he had gone to school. He told me that he got his MBA at UCLA and his PhD in economics from the University of Southern California. I inquired:

> **"What the hell are you doing in here?"**
>
> **He thought a moment, then said, "To be honest with you, I was running my business out of a briefcase, and it was snowing all the time."**

A few weeks later, some of the first inmates were about to graduate

from the program. One asked the instructor what happened to graduates. He told them that they would be sent to prisons that were installing solar systems to get some hands-on experience before being released. The inmate asked what prisons had installations going on. The instructor replied San Quentin and Soledad, which are maximum-security prisons with frequent brutal violence, in contrast to medium-security Corona-Norco with the gold-plated swimming pool.

A sudden chill swept across the room.

> The inmate said, “Let me get this straight. When I graduate, you’re going to transfer me from this nice medium-security prison to a war zone?”

The instructor affirmed this.

> “I ain’t graduating,” said the inmate.

He walked from the room, and every single other inmate did the same. End of program. A little fender bender on the road to widespread solar energy.

Teaching At the Real Law School

I was also teaching alternative energy law at Whittier Law School, my alma mater, and one of my students missed the final. She claimed her husband had been diagnosed with a brain tumor the day before and she had to take care of the situation. I went to the

dean to get permission to give her another final, and he said:

"Oh, did she use the brain tumor excuse again?"

Turned out it was the third straight semester she'd done this. A for creativity, F for redundancy!

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I had one assignment for the students that required them to speak to a businessperson in the solar industry, the gasoline station business, and a big oil or utility company. The one question they were required to ask was: "How often do you see a lawyer?"

The solar folks saw a lawyer once a year or so, to learn about new government incentives. The gas station people depended on the oil company lawyers. The oil company or utility executives spent over four hours a day with them.

The best lesson, though, came from the gas station operators who had been fined five thousand dollars per day for charging more than allowed for gasoline. They made twenty thousand dollars per day extra by charging more and would just cut a check for the five-thousand-dollar fine, no questions asked—needed to get out and do some more pumping.

Chapter 10

JPL General and Space Stories

These next stories don't have much to do with energy. JPL was mainly in the deep space business. Most of the lab was engrossed in the deep parts of space that only satellites could get to. Our energy work was a small part of JPL's work, and it seeped into the lab's consciousness only occasionally.

On the other hand, the space stuff was very cool—major-league toys, exquisite beauty, exotica. We always tried to get involved where we could. It was great fun and a nice vacation from the urgency of our energy and environmental work. The next few pages include some of the non-energy stories.

The Sex in Space Program

I love this story.

JPL got the assignment to design the conjugal bed for the International Space Station. Apparently, folks trying to join the two-hundred-mile-high club had a problem: when one person thrusts against another in space, they both go in the direction of the thrust until a wall gets in the way.

Volunteers for this "research and development" effort registered at an all-time high. Jacuzzis all over Pasadena were commandeered as simulated weightlessness conjugal test facilities that required careful scientific (and sometimes engineering) attention. That is my story and I'm sticking to it.

We interviewed a lot of people to get suggestions, and boy, did we get them. Velcro garters, bungee cords, padded rooms with

handholds, fur handcuffs, giant clamshells, and something involving ice cube trays all received multiple endorsements. So much so that, after a while, we often ended interviews with comments like:

> **"Ya know, there's a guy (or girl) you should meet. You two have a lot in common."**

It became a sort of dating service. At least one couple is still together, a happy little clamshell.

A PhD in "Kick It"

I heard on the radio one day that something was stuck on the *Voyager* spacecraft and threatened the whole mission. Then I heard on the radio that "JPL scientists had sent up new programming from the ground" and had solved the problem. I asked one of the *Voyager* scientists if he knew what the "new programming" was. He explained that something was stuck inside the satellite, so they programmed a camera arm to fully extend and then rebound to strike the satellite body right near the stuck part. This new genius science programming stuff was that *they kicked it*.

It's Raining

My first day on the job, I was in a van going to the JPL personnel office in the pouring rain. I remarked to the guy sitting next to me, "It's raining."

He asked, “Are you sure?”

I asked, “What else could it possibly be?”

He said, “Water falling from the sky.”

I asked, “What do you do?”

He replied, “I’m the chief meteorologist for NASA.”

I said, “You know too much; it’s raining.”

Uranus? Is There Another One?

Early that first day at JPL, I was at my desk when a brown-haired middle-aged man with a slight paunch and a leather jacket wheeled his bicycle into our room. He took off his leather jacket. Hung up his helmet. Kicked off his shoes. *Took off his pants* and hung them on a hook, and proceeded to sit cross-legged in his mighty-whitey underwear on one of the gray army surplus office chairs we used. He then pulled out a restaurant-sized *jar of peanut butter* and a *serving spoon*, took a big *shmear* of the peanut butter, stuck it in his mouth, finally noticed me taking in the show, burbled a hello through the gooey peanut mess in his mouth and started laughing. Rich Caputo and I have been friends ever since.

Because of Rich’s sartorial business attire in flagrante, the typists (yes, we used typists back then, a now nearly extinct species vaguely related to the triceratops) would walk into our office backward to avoid looking at Rich’s “fashion statement.” Rich

wrote speeches for the director of the lab, so the typists would come in waves to pick up changes and deliver drafts. They'd walk backward a few feet into the room, then hold the papers out behind them for Rich to take. Sometimes they'd just leave the papers at the door; then Rich would poke his head out, and, if the coast was clear, grab the papers and jump back in the room—fast.

Rich is crazy, talented, brilliant, nice, funny—a great mentor for me. He was also responsible for at least three extraordinary scientific and engineering masterpieces. The best had to do with the *Voyager* spacecraft, which is the first man-made object to have left the solar system, and after more than thirty years is still sending information back to earth. Although the *Voyager* was originally designed to run out of energy after passing Saturn (around four years), Rich and six others bootlegged the materials and modified the design so it would go for many decades, not just a few years. I personally think *Voyager* is one of the ten greatest engineering achievements of all time, certainly of the twentieth century, and Rich was one of the greats who made it happen.

The second masterpiece led to the largest natural gas finds in history. Rich noted that millions of years ago the earth's atmosphere was mostly natural gas, and asked:

"Where did all that gas go?"

Since the time that question was asked by Rich, we've found gas in coal and shale, trapped under lakes, and in thousands of places no one expected.

The third masterpiece was a very simple way of figuring how much of what we pay for energy, and even medical care, is "social costs."

When you do all that, I guess you don't have to wear pants if you don't want to.

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Three months later, JPL had just successfully flown the *Voyager* spacecraft by Jupiter, and it was on its way to Saturn. Congress had that day authorized JPL to continue the *Voyager* mission for several more years. The new authorization was for something called the "Grand Tour," in which the spacecraft would travel past Uranus and Neptune before flying out of our solar system into interstellar space. This is what Rich and his cohorts were dreaming of when they bootlegged the nuclear battery. Man's first attempt to leave our solar system and communicate beyond it was made possible by not following orders. So American.

Bruce Murray, JPL's director, was worried about the press conference happening in the next hour, with live hookups to dozens of countries. He showed up at our door and said, "Rich, I can't go on television and tell five hundred million people that we're flying to Uranus [pronounced 'yer anus']. What do I do?!" Rich, with a sandwich's worth of peanut butter in his mouth, answered, "Call it Uranus [pronounced 'urine us']." Murray exclaimed, "That's a great idea; that's exactly what I'll do!" And that's what he did.

That night on NBC's national news broadcast, the sonorous anchor, Tom Brokaw, announced at the end of the program that NASA/JPL was flying to "urine us"; then he looked in the camera and cracked up.

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One of the coolest things about *Voyager* was the thick gold record secured to the side of the spacecraft. Pictographic instructions on how to assemble a player to listen to the sounds were engraved into a plaque alongside the gold record.

The record is truly one of the great assemblages of human sounds ever collected. It has superb examples of music from every corner

of the globe, along with lovingly selected sounds of babies, heartbeats, trains, whales, and other samples. And in addition to these prime examples of our sonic world, leading off the record are fifty-five speeches from world leaders in their own languages.

Think about this a second. This is humankind's first organized attempt to leave our solar system and to tell unknowable but knowing organisms about ourselves. Billions have been spent, and the skill, hopes, and dreams of almost everyone on earth are riding in some ancient way on this thing. The eternal quest to reach out to other worlds. And the first thing this poor alien has to do is sort out fifty-five different languages?! I don't know about you, but my English is OK and I know a bit of Spanish and some tourist Thai—that's my max. I know a couple of people who speak six languages, but fifty-five?

On the side of the spacecraft are instructions for a RECORD PLAYER. *A record player*. Most people alive today have never seen or heard a record player, which have now been replaced by iPods and CD players, which didn't exist when *Voyager* was launched. And this record player has to play pictures, too. Dealt with RPMs on your record player lately? Maybe your grandfather did when he was a kid.

There are a few really funny things in those speeches, though. First of all, the recording starts with a few words from then Secretary-General of the United Nations, Kurt Waldheim. It later emerged that Waldheim was in fact a relic of the Nazis from World War II. So the first words this inhabitant of another world is going to hear will be spoken in heavily Austrian-accented English: "I send greetings on behalf of the pipple [people] of our planet." From a Nazi.

After a babble of a dozen or so languages, a voice comes on and says, like an emcee at a club in the New York Catskills, "HELLO, EXTRATERRESTRIALS." And then a little while later, another voice says: "As you probably already know, we are a question-mark-shaped country on the west coast of Africa."

“As you probably already know”? Can they see lines from space? Do they already know that Kurt Waldheim was a Nazi? What an interesting set of assumptions the speakers must have had.

The alien is going to need a space martini after listening to this thing. At least it’ll have a record player.

I recently had a chance to go back to JPL and give a speech. Part of our job had been to predict the energy future twenty or thirty years hence. That was thirty-one years ago, so I had the chance to talk about what we’d gotten right and what we’d gotten wrong.

The best thing about the speech, though, was that a full-scale engineering replica of *Voyager* was right next to the podium, while the *Cassini* spacecraft flanked the other side of the stage. Both were wrapped in the shiniest gold foil you can imagine. A display about the sounds on the gold record was at the base of the stage stairs. That was so cool.

We’d definitely gotten some things right: the hybrid and electric car, oil prices, underground gasification, personal computers, even specific corruption and criminality. But we missed a few things too: the Internet and cell phones.

Lesson: everyone just has a batting average when it comes to predicting the future. I once made something like a hundred great decisions in a row—and then screwed up for the rest of the decade.

There Is a Solar System in My Oatmeal

I'm having breakfast one day in the JPL cafeteria and start chatting with some guy sitting next to me. We have the usual work conversation: "What do *you* do?" (Navigator for a future mission to Jupiter to be managed by JPL called Galileo.) "What do *you* do?" (Energy policy analysis.)

He explained to me that, because of the *Challenger* Space Shuttle crash and tragedy, solid fuels could no longer be used to power interplanetary space missions, but liquid fuels weren't powerful enough to get the spacecraft to Jupiter as in the earlier *Voyager* missions. They had no way to get their Galileo satellite to Jupiter.

I was eating oatmeal. He took it and smoothed out the surface, arranging raisins and walnuts to represent our solar system —"This walnut is the sun and this walnut is Jupiter, this small raisin is earth and this cube of sugar is Venus"—until he had the whole solar system in there. Then he started drawing lines in the oatmeal with his finger while withdrawing into his own thoughts. He drew some circles around raisin-earth and explained that you could go in fast orbits around earth and slingshot to Jupiter, but you still needed more energy than could be provided by liquid fuels. His slingshot mimicry sent oatmeal flying toward the big sun of a walnut, and he said, "The orbit's not big enough." Then he started musing to himself, "But you know, if we made the orbit all the way between Venus [sugar cube] and Earth [small raisin], we could build up enough energy to get to Jupiter!" He was drawing circles all over the cereal now, and oatmeal was flying everywhere, including on my shirt and his arms. He got really excited and ran from the table, leaving my oatmeal to congeal and the planets to drip off the table and onto my pants.

And believe it or not, that's exactly what they did. They called it

“VEEGA,” for Venus-Earth-Earth Gravity Assist. Galileo would slingshot once by Venus, and twice by Earth, gathering enough momentum to get to distant Jupiter. And it all started in my oatmeal.

Space has taken up enough space,

back to the energy stories…

(The current holders of the “biggest universe” prize have to be the string theory physicists, who have come up with eleven different dimensions, each with their own infinity!)