DISCOVERY PROGRAM ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

KEN ATKINS
STARDUST PROJECT MANAGER
INTERVIEWED BY SUSAN NIEBUR
JET PROPULSION LABORATORY – 10 AUGUST 2009

NIEBUR: Today is August 10th, 2009, and I'm speaking with Ken Atkins, who was Stardust Project Manager first, and has also had a number of other duties while here at JPL. My name is Susan Niebur. I'll be conducting the interview. We are at Jet Propulsion Laboratory in the mall. So, Ken, tell me a little about yourself.

ATKINS: Well, I was originally from Texas, grew up in Amarillo, and born in '37, so a child of World War II era to some extent, became a little boy interested in airplanes, made a lot of models, played baseball, big conflict between baseball, airplanes and then learning about whatever else was going on in the world. So, went through high school and baseball had won out, but as I approached graduation I thought, okay, I've played high school baseball, now I have to figure out what I'm going to do about to college and life after that.

I had an uncle who was a World War II pilot, and I remembered my love of airplanes. I thought, you know what? I think being an Air Force pilot would be a wonderful life. That's what I ought to do. I want to fly. I had gone to airports nearby and tried to get rides on my bicycle when I was younger, but I didn't—I never could get a ride. I don't even think I had a flight in a real airplane by the time I was about a junior in high school.

I developed a plan. I was earning money to go to college with a part-time job driving a little ice cream truck. I used to sell ice cream to the kids and stayed in trouble with their mothers

who didn't like me coming around at naptime. Anyway, I was making a little money and I still had time go to baseball practice. I felt I needed to start flying ASAP.

So, I took my ice cream truck after I had finished my route one day and drove out to a nearby dirt strip airport and walked into the hanger and talked to these guys and said I wanted to learn how to fly. I had on my white ice cream suit and that drew some interest since it would make an unusual "flight suit" for my first lesson. But, to them, a customer was a customer so they took me out and introduced me to the Piper J3 "Cub." My plan was to do this flying training in secret from my parents and everybody else. This was for two reasons. First, being an only child I didn't want to worry my parents. And second, I might not be able to do it at first and failure was not an option—at least publicly. My plan was to take lessons until I soloed. I found the thrill of real control in flight. I was hooked. Flying became everything. After about 9 hours of instruction, he climbed out after a couple of practice landings and said, "Take her around by yourself." Wow. By this time with high confidence I pushed the throttle up and clattered into the sky—alone. After the small celebration at the airport, I went home that night and, right at the end of supper, told my parents I'd soloed an airplane, which was kind of an interesting time.

First there was a sort-of stunned silence, like this must be a dream or something. I'm sure it sounded totally incredible. I followed the premise: "begging forgiveness is better than asking permission." Since I was an only child, for my parents that was, I'm sure—now having been a father and grandfather—a real shock! I can imagine. [laughter] But they were very understanding. In those days (August 1955) there was a lot of freedom for kids in the Texas plains. 14-year-olds were driving tractors. I got my driver's license at 14. I would duck hunt with a shotgun at 16. So, we were familiar with risks and things like that in that part of the

country. It was part of the culture in my parents left over from the depression era thirties where kids in the "Dust Bowl" grew up fast, worked early, and went to war. I'd just turned 18.

I began looking for a school that would support my plan for an aviation career. I was reading a Flying magazine at the barber shop one day and came across an ad from St. Louis University. They touted one of their colleges, Parks College of Aeronautical Technology, that offered some really interesting aspects. It had a curriculum where you went 11 months each year with one month off and you could get a Bachelor of Science in aeronautical engineering degree in 33 months of study. They also had Air Force ROTC. So, I decided this was perfect for my plan. I went to Parks College in the fall of 1955.

Some very interesting people have come from there. Gene Kranz, who became the very famous Apollo Mission Director, was a graduate. I studied aeronautical engineering and pursued my Air Force pilot training entry through joining ROTC. I spent those three years living a dream of being immersed in everything about airplanes and flying. And I well remember exactly where I was when the Soviets stunned the world with Sputnik. But one of the most fantastic flights was meeting my future wife, Barbara, at a nearby women's college. I was flying on all fronts when she said she was willing to cast her lot with a future Air Force flyer. I graduated in 1958, she pinned on my Lieutenant's bars, we followed quickly with our wedding and my slipping a ring on her finger. Both wide eyed and seemingly without a care, we went off to Class 60F and pilot training.

And with her support, I went through pilot training with honors and succeeded in becoming a jet pilot. Another great event was having her pin my silver wings on at the graduation. I chose to go to the Strategic Air Command and fly aerial refueling tankers because I thought I wanted to eventually be an airline pilot. SAC turned out to be a good place to go to get

that out of my system because flying 10-hour missions with a lot of boredom involved in it was something I learned I didn't want to do as a career.

One night I got a call from SAC headquarters in Omaha, Neb. A Colonel told me about a new program involving intercontinental ballistic missiles (ICBMs). These were nuclear weapons to be based in underground launch facilities in Montana. The Colonel said, "We've studied your records. You have an engineering degree. This program is highly technical and in its early phase needs crew commanders that are trained in engineering disciplines. We're recruiting people like you and as an incentive; we are planning an advanced education element where we will send professors out from the Air Force Institute of Technology (AFIT) at Wright-Patterson AFB in Ohio. They will graduate you with a master's in aerospace engineering. You'll still be able to maintain your flying proficiency and study while on "Alert Duty" at the missile sites."

I thought this sounded better than continuing to do what I was doing which was being away from home a lot on "temporary duty (TDY)" trips to a small SAC Alert Facility on Canada's Hudson Bay (Ft. Churchill, Manitoba) and flying long, mostly boring refueling/training missions when home. The "alert" trips were part of SAC's job to have refueling tankers always ready up near the departure point for our bombers toward the Soviet Union in case of a retaliatory war strike. This was part of the "Mutually Assured Destruction (MAD)" policy during the Cold War. In addition, continuing my education seemed like a smart play to me since I was coming to believe flying airplanes for the rest of my life was no longer an attractive option. So we went to Montana in 1962 and stayed there until I completed my MS in Aerospace Engineering in 1966. It was a tough assignment though. I didn't really understand when I took the ICBM job that it really involved three very demanding jobs that were filled with pretty high levels of stress and options for failure. First was acquiring and maintaining a high

proficiency as a crew member in charge of nuclear missiles. This involved a lot of training and scrutiny for military officers in charge of a launch site controlling 10 nuclear ICBM's that could have blown up as much as you could imagine. The concern was that unless we had highly trained and disciplined crews some wacky schemes might be dreamed up to make the "Dr. Strangelove" fantasy look like a real possibility.

We had two-man crews and a control process that really precluded such a disaster, but any kind of incident or accident could have world-wide implications. So SAC was very cautious and focused on stringent training and discipline for its officers. We were the very first in a brand-new deterrent weapon system. In fact, in this first Wing of *Minuteman* crews, I turned out to be on the 12th strategic "combat ready" crew ever to take on this kind of responsibility. A lot of people were very interested in how we operated and what our psychological and character background was.

NIEBUR: I would bet.

ATKINS: Yes. The USAF was following the regimen developed by Admiral Hyman Rickover, known as the "Father of the nuclear navy." He came up with a very famous interview process for selecting all the naval officers operating/commanding nuclear ships. His care in the psychological and character filtering of these officers was credited for the Navy's record of zero nuclear accidents in a force that involved some 200 nuclear-powered submarines and 23 nuclear aircraft carriers and cruisers.

The central headquarters for my new assignment was Malmstrom AFB at Great Falls, MT. The *Minuteman* ICBM structure was three "squadrons" of 50 missiles each. A squadron

consisted of five remotely located launch control centers (LCC's), scattered on farms and ranches over many, many square miles and buried in a concrete and steel "capsule" 60 to 70 ft underground. Each LCC monitored and was prepared to launch (on command of the President) 10 of the nuclear solid rocket warbirds in just minutes. The launch "silos", burying the rockets under fifty-ton blast covers, were electronically networked and scattered roughly in "rings" around the LCC's. I found it ironic that here I was, an expensively trained jet airplane pilot who formerly operated at high altitudes, now enmeshed in a "Jules Verne" system deep underground and guarding the country from this subterranean lair with a destructive power far beyond all the explosives used in all wars—total!

NIEBUR: I'm a history buff, so I'm fascinated.

ATKINS: Well, this Nuclear Launch Officer responsibility was the first of the three-legged stool of stress I found myself sitting on. I'd been promised I wouldn't have to give up my first "love" in the Air Force, flying. SAC provided some airplanes on the base for those of us who were pilots to maintain our flight proficiency. This flying operation included instructors and check-pilots to keep us professional and sharp. In the aerial refueling squadron I'd come from, that was my only (and full time) job. Now, it was an additional duty. This meant check-out and flying a different kind of aircraft. For proficiency there were the training flights with take-offs, landings, instrument flying and even some missions to do. Once when soaking rains flooded areas north of Great Falls, I found myself flying a de Havilland "*Beaver*"—a single-engine, high-wing, propeller-driven, STOL (short-field take-off & landing) aircraft, primarily known as a bush plane—picking up stranded families and flying them out of situations where their homes were

being surrounded by water. Maintaining flight proficiency thus came in as the second leg of the stool.

Finally, I now was committed to one of the key reasons I accepted the *Minuteman* assignment. I became a grad student. SAC had arranged a great set of classrooms and labs for guiding us toward our master's degree in aerospace engineering. This third leg of the stress stool brought top professors from the Air Force Institute of Technology (AFIT) at Wright Field in Ohio out to Montana. The profs would come for a semester and rotated in and out to teach us engineering mechanics, nuclear physics, quantum mechanics, advanced math, fluid dynamics, space propulsion—the whole nine yards to earn the master's degree. In effect this added a third "full time" job of study, homework, and testing to two I already had. I faced a triple threat of failure.

So, it was really a time that almost drove me crazy. And I was married to Barbara, the most beautiful woman in the world, and we were new parents of a son. Wow! The demands and priorities also threatened my most precious asset—my family. My life's schedule was tough, because I'd go out on a 24 hour "alert" duty to crew the LCC, come back home pretty exhausted from the rigors of working out the bugs in the new weapon system, try to get some rest, get up, get the homework done, fly the next day, go to class, attend to squadron demands and meetings and - then go back and do it again. It just went like that. I'm not sure how I made it work through almost four years. One highlight of this grad student education was a course on "nonchemical space propulsion" that treated a real "Buck Rogers" technology. The idea, captured in a textbook authored by Dr. Ernst Stuhlinger of the Marshall Space Flight Center, involved ionizing (electrically charging) a gas by electron bombardment and then exhausting it as a high velocity beam to drive a spacecraft with low thrust over long periods. This really captured my imagination since I'd read some hints of this in science fiction books that had

drifted sporadically through my junior and senior high school days. I mention this because it eventually provided the connection for me to come to NASA and JPL.

Anyway, I was almost through this gauntlet by 1966, and by this time, the Vietnam War was heating up. With my now-certain graduation from the "*Minuteman* Education Program (MEP)" as it was called by SAC, I had an opportunity for my next assignment to exploit my upgraded engineering skills at Cheyenne Mountain in Colorado Springs working with the North American Defense (NORAD) element of the Air Defense Command on orbital tracking and definition of space objects and threats.

NIEBUR: That's a good offer.

ATKINS: Yes. That was going to be wonderful. I'd gone down there and interviewed with some people and the assignment seemed thoroughly "wired." But Robert McNamara the Secretary of Defense under Lyndon Johnson, was learning that the emerging involvement in Vietnam was placing heavy demands on all our pilots. It became clear we needed more than then assigned to the effort. An edict came down that all pilots not in flying jobs were required to return to the cockpit. That, of course, included me!

NIEBUR: Really?

ATKINS: Yeah.

NIEBUR: Okay.

ATKINS: Naturally, I was very upset. I had gone through all this hell and my chance to use my new technical skills was gone. Fortunately, since I knew too much about SAC's strategically integrated operations plan (the "SIOP"), there was a prohibition on sending folks like me directly to Nam. They sure did not want me to be shot down and captured. Now there, I had strong agreement with HQ. I had to be used for a time as "back fill" for deploying pilots in order to let my memory "volatilize" and for the SIOP to evolve to a state much different than what I knew. There was a certain amount of sympathy for us MEP pilots because SAC knew how tough the regimen had been and they now really valued our toughness and discipline, I think. Anyway, they tried to place us in a flight job we might prefer for that time. So, they said, "Well Captain (by this time), what would you like to fly?" And I said I had always been interested in the Air Force's supersonic trainer, the T38 "*Talon*." It's a "sexy" (even today) high-performance twin jet airplane and the mainstay of the last phase of pilot training before getting one's "wings."

NIEBUR: Nice.

ATKINS: **"**If I'm going to have to go back to the cockpit," I said, "I'd like to fly that." So, they said, "You've got it." So, I found myself headed south from Montana to Reese Air Force Base near Lubbock, Texas and I started checking out in the T38. I was headed for qualification as an instructor pilot. Wow—I really got a kick out of that airplane. But then the future started to darken. Guys were coming back from Vietnam to instructor slots at Reese as instructor pilots rotated to replace them in Nam. This was in early 1966 while we were just emerging from being only "advisors" in Nam. Pilots had been just "disappearing" and those surviving were in limbo

in a place that eventually became notorious as the "Hanoi Hilton." This looked like "men without a country" to me. They had been doing a dangerous, unrecognized, and thankless job because of our national policy. It had been "secret" like this until the controversial "Gulf of Tonkin Incident" in August 1964 that served as a pretext for Congress to pass the Southeast Asia Resolution, granting President Johnson the authority to recognize and escalate US military operations in Southeast Asia without the benefit of a declaration of war. The incident involved a claim that North Vietnamese torpedo boats had made an unprovoked attack on the destroyer *Maddox*.

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Anyway, these guys had come back from doing combat work in Vietnam. And it was just a—

[break in audio, as we moved away and regrouped at an adjacent table].

NIEBUR: I'm enjoying this, so don't you worry about me.

ATKINS: Okay. I hope you are. You can stop me at any time.

NIEBUR: I'm totally enjoying this.

ATKINS: It's kind of an interesting story.

NIEBUR: This is part of two with Ken Atkins on August 10th, 2009, so I can find it later.

ATKINS: So anyway, this was about the business of Vietnam and pilots fighting in a situation without national support or even awareness. This seemed wrong to me—brave men being "written off" as non-existent and facing a potential future of disappearing without a trace into a captivity of unknown proportions. It was about an Administration not willing to fight to win a war. It was one of those deals which brings a sort of déjà vu even today with young men who are battling in places that are very difficult and the country still has this, well, dichotomy about its will to fight. In those days, we still had the draft. Of course, I'd joined as a volunteer because I wanted to fly. I had signed up for that, but certainly had taken an oath to serve my country. I wanted to fly airplanes and I had been willing to do whatever was necessary.

But then, I saw what was going on from the standpoint of guys coming back, highlighting a perverse approach by our national leadership and what we were doing. I had a choice to make. So, fortunately for me, I was able to resign my commission.

NIEBUR: Really? Even at a time of war?

ATKINS: I was able to get out because I had nine years in the service and I had done a lot of things. I had, in fact, been right there "on the button" during the Cuban Missile Crisis. Anyway, now I was in the Air Training Command (ATC). And they had self-interest in how they treated my situation. I was one of the first to graduate from SAC's MEP and now had years of operational experience. ATC had the job of training and supplying the *Minuteman* crews but no teachers that had ever actually done the job. Now they had one and saw the opportunity and value of that to the missile training program at Chanute AFB in Illinois. So we made a deal. I had to give up my flying status as a pilot in return for spending my last two years of service

commitment training crews for duty in the missile program. I wasn't happy about leaving flying but I was glad to avoid putting myself and family through the uncertainty of my surviving combat flying in Vietnam. I now also had a daughter born in 1966.

We moved to Chanute AFB which is located about 20 miles north of Champaign-Urbana, the location of the University of Illinois. The time was when the Apollo program was fully in the national spotlight and preparing for the moon landing that came in July of 1969. I was in back graduate school because I felt that the best opportunity to find a job would be through contacting companies that came to U of I to recruit. I worked my schedule such that I could train Air Force *Minuteman* students on the morning shift and go down to U of I in the afternoon to stay academically sharp and seek company interest. I got involved with the aero department down there and looked for ways to increase my knowledge of electric space propulsion (recall my course in Montana). I put together a resume and all that stuff. It turned out the Apollo Program was ramping down, so the interest by companies in engineers was too. As I separated from the USAF in 1968, I was faced with no job and only savings for supporting my family. My entry into UI before leaving the Air Force provided crucial help.

They offered me a research assistantship, and I said I haven't got a Ph.D. And they said, well, you might as well work on that while you're trying to get a job, so I did. I focused on my interest in advanced space propulsion and Stuhlinger's textbook *Ion Propulsion*. Stuhlinger had been one of von Braun's men in Peenemunde during WWII. He was one of the German V2 program people that surrendered to the Army and were sent to Huntsville AL to work for the USA. He was quite an interesting guy and was at Huntsville during the time I was in Montana.

Later, at JPL I had the privilege of meeting and working with him on studies of ion drive space missions.

At UI I started to try and find somebody on the faculty that would help me with a dissertation on ion rockets. Well, they didn't have anybody in the aero department that did ion rockets, they were still all about aerodynamics, but it turned out that the electric engineering department had some grants from the Air Force looking at spraying colloids—electrically charged droplets—as rocket propellant. This was a perfect match. It's an interesting "side note" that this kind of research eventually became a spin-off that led to today's ubiquitous ink jet printers.

So, it was through that process and working on a Ph.D. in ion rocket propulsion that I finally was able to attract an interest by JPL. They were interested because they were just beginning to do some advanced mission studies that might benefit from the features of ion space rockets. By this time I was near completion of my PhD and the timing was good. I got an interview trip out to JPL and they offered me a job in 1969.

So, I came out here and started doing studies on ion rockets. Through these I was able to show that ion rockets with low thrust are very good for getting to small bodies like comets and asteroids. The reason was that such bodies are without any significant gravity since they are so small. This meant the g-field couldn't help capture an arriving spacecraft with a crossing trajectory. The idea was to match the spacecraft trajectory exactly with the comet. In essence, fly in formation with it. Ion rockets can shape a spacecraft trajectory enroute to do just that. And so, I worked mission studies on flying ion rockets to different comets.

And then, Halley's Comet started picking up interest in advance of its coming back through the inner solar system in '83, '84. By this time I was working in JPL's Advanced

Projects group. The group was funded by Headquarters to look at new ideas and options for robotic space missions at JPL.

We were the ones who came up with the idea of using gravity-assist for planetary exploration, for example, sending a spacecraft through a body's gravity field to add energy to the trajectory. We'd used it on Voyager sending it to visit several of the giant Outer Planets: Jupiter, Saturn, Neptune. For Halley's Comet, one of the fellows in the group came up with the idea to solar sail (e.g. use the pressure of sunlight) to perform the rendezvous (fly formation with) the comet. This caught the imagination of the famous scientist, Carl Sagan and our JPL Director, Bruce Murray. They pushed this "exciting mission" in a great PR campaign that even had them on "The Johnny Carson" show. They were getting a lot of publicity. I believed the "Sail Option" was pretty "far out" and thought it very risky. I believed it was uncompetitive with ion drive. And so, I fostered a "challenge" competition between solar sail and ion rockets to fly a mission to Halley's Comet. It just made sense to do a real comparison and select the plan with the highest probability of succeeding. And I found myself the leader of the ion rocket team. Lou Friedman, who's now the Director of the Planetary Society, found himself as the head of the solar sail [team].

NIEBUR: Sounds exciting.

ATKINS: Oh, it was a lot of fun. Lou had buttons/badges made for his supporters and passed them out like candy. I think he was the first to come out with these kinds of mission pins. His pins used the slogan "I'm a solar sailor." By this time, I had gotten a lot of interest in electric propulsion. I, by this time, personally knew Ernst Stuhlinger, the Penemunde German ion rocket

engineer because I had been in AIAA and I had met him in that context. Anyway, NASA set up a "shootout" over a summer and put together an Evaluation and Selection Committee with consultants from companies such as SAIC and some very smart people like John Niehoff, Alan Friedlander, and others to gauge each technology option for the mission and recommend the "winner" to go forward toward gaining approval for funding and implementation. I was very confident that the ion propulsion option would win because NASA, in its Office of Aeronautics and Space Technology, had, for years, spent a lot of money researching and actually testing and flying some small ion rockets. They had Hughes Research Center at Malibu, CA as the contractor providing these "little guys" to satellites to provide attitude control. Lewis Research Center (before its name change to Glenn) in Ohio was the lead technology center and had even done a space test on a larger engine. This mission, called Space Electric Rocket Test (SERT) had been very successful. So, I had a pretty good group of support folks that worked hard on the Ion Drive option for Halley's Comet. The technical maturity and strength of research support for ion rockets, as I suspected, won the day. The NASA committee selected the ion rocket. Unfortunately, there was no money for it because the Carter Administration had a rather tepid support for planetary science missions, and—long story short—they decided that they would support research on "black holes" rather than work on getting something to Halley's Comet.

During the "shootout", my team had been working with the Europeans to add an international dimension to the mission and I had changed the Halley mission from a what we viewed was a very risky rendezvous mission to a simple flyby of Halley's Comet where we would carry and drop off a European probe to plunge into the dust cloud shrouding whatever was in the "head" of Halley's Comet and, in "Kamikazee" style, snap some pictures before being destroyed by the very high velocity particles and, probably, rocks that make up the cloud. For

the United States part we would stay clear of the danger and, after the drop off, would fly on and do a full rendezvous with an easier-to-reach comet called Tempel. I think it was Tempel II. When the Carter administration finally shot us down, the Europeans, non-plussed about that started their own program called *Giotto* and by default the USA dropped out of exploring comets, for the time being. *Giotto* turned out to be partially successful and got a vague and intriguing hint of what a comet nucleus was by getting, I think, only one picture, before it was hit and tumbled about in its extremely brief pass inside the dust cloud.

Personally, since my team effort on a real mission had folded, I dropped back to continue toward R & D for eventually getting ion rockets on planetary spacecraft. It turned out that JPL had some electric propulsion technology work funded by OAST in a group (Section) here that did all the electric power systems for JPL's spacecraft. All the publicity of the Ion Drive/Solar Sail competition had provided me a lot of attention and exposure. I ended up being offered the job of manager of the Power Systems Section. The responsibility included batteries, power electronics, solar cells, radioisotope thermal electric generators (RTGs), along with the work on ion propulsion. And I was there for eight years. My narrow focus on just ion rockets became diluted over time as I learned a lot about management and projects as we delivered power subsystems to a string of JPL missions from *Galileo* to *Cassini.*

The section was organized around two themes. One supported the funded flight projects and was very risk averse. Only the "tried and true" would do. The power subsystem, of course, is the "blood stream" of any spacecraft so it has to work. The other theme/emphasis was research and development. Here we were doing electric propulsion engine and power processing technologies, advanced solar cells, power electronics and advanced batteries. The idea was to try to get the technologies to a maturity that would warrant the confidence of a flight project user.

The problem was getting across the divide from technology to actual flight without scaring project managers to death with things that are brand new; technology readiness was a very subjective barrier with a very objective criterion called "risk of mission failure."

NIEBUR: Sure. A really important part of the step. It has to be there.

ATKINS: It is. Trying to bridge this gap was very difficult. For example, JPL's standard for all the time that I'd been here was to use mechanical relays (switches) to route power on spacecraft. Well, when we came to *Cassini*, we needed the efficiency and mass-savings promised by digital switching. In addition, the use of solid-state and non-moving parts also promised to reduce risk—if they could be built and tested to space requirements. And so, we started looking at digital switches. That's one of the examples of a difficulty getting across the line. We were able to make that transition, but it was difficult.

NIEBUR: What was the digital switch on? Could you explain to me—on *Cassini*? You're talking about—.

ATKINS: On *Cassini*'s—the mission to Saturn—power subsystem.

NIEBUR: On the power subsystem, okay.

ATKINS: What we had to do is use a different and new technology in providing power to all the subsystems on the spacecraft. It involved managing roughly 500 watts needed for a typical

planetary spacecraft. And before, we'd always done that with a lot of mechanical relays. They had to be redundant and all kinds of things. Doing them electronically would be more reliable, if you ever got the technology to an acceptable state of readiness.

NIEBUR: Reliable, yeah, of course. Wouldn't we all?

ATKINS: Anyway, I spent those years after the "Halley Project" learning a lot about project development, leading a team of people and certainly, a very important experience in standing in the gap between the cultures of research and development and the actual flight implementation where anything new or that hints at all of risk is to be avoided like the plague.

Then, your Discovery Program comes up. NASA's Administrator, Dan Goldin, and JPL's Bruce Murray were hearing from the science community—as Clinton's administration squeezed NASA and aerospace as a product of the "peace dividend" after the Cold War—that doing investigations and exploration with instruments aboard spacecraft was in a deep funk. The planetary space program consisted of primarily "flagships." These were many-year expensive projects centered on a single spacecraft with a suite of maybe 5 to 10 instruments aboard. These were "few and far between" projects and tended to have the same group of scientists just sequencing from one to the next. This meant a small, shrinking opportunity for the broader community of scientists across the country and their grad students to participate. What was needed from Dan Goldin's perspective was many missions that were inexpensive and, therefore, available to a wider constituency. He wanted a "Faster, Better, Cheaper (FBC)" character in planetary sciences. So, they came up with having the broad science community meet together bringing their ideas. The group could then discuss them in attempt to match and prioritize with

NASA's overarching goals. The missions would be funded in a cost-capped allocation with the Principal Investigator (PI) in charge. He/she could select an industrial partner and the project management partner as well. This would in a way mimic a program called *Explorer* aimed at small, affordable Earth-science missions. Goldin dubbed the program Discovery. I knew nothing about it because I was perfectly contented on my path to retirement as a power systems section manager and delivering them to flagship projects for the rest of my career.

To "seed" the program, NASA took three existing small projects they were funding. These were *Lunar Prospector*, the *Near-Earth Asteroid Rendezvous* (NEAR), and *Mars Pathfinder*. To begin the competitive process that would be followed, they requested proposals from which NASA would "down select" the next, Discovery 4, mission. They received 23 or 24 of them, as I recall, and they started the process. In fact, I got involved in that because of my background in "small body" (a.k.a. comet & asteroid) missions. One of the proposers was Professor Frazier Finale from the University of Hawaii, who was an aficionado of asteroids and wanted to do an asteroid sample return, he called it the Asteroid Earth Return (ASTER).

As an additional duty to my Section Manager Job, JPL asked me to lead the team preparing the proposal with Lockheed-Martin Astronautics (LMA) as Frazier's industrial partner. To do that, we had to figure out some way to get the sample and bring it home. .

Suffice it to say that we recalled that the Air Force had a technique back in the 1950s that used canisters to return film taken aboard our early spy satellites. The film canisters were dropped from the satellite and parachuted down toward Hawaii. There, our C-119 USAF aircraft flew over the chute trailing a big wire loop that snagged them and reeled them into the cargo bay.

NIEBUR: Right, right.

ATKINS: Some of these canisters still existed so we located them and proposed to use that technique.

NIEBUR: Really?

ATKINS: Yeah. We talked to people at GE who'd been in that program. I think they were in Valley Forge, PA. In fact, we'd thought about doing this as an option for the Halley mission back in the 1980s. It was funny because we'd considered, at the very end of the Halley study, to cut the cost way down by just going for a flyby of Halley in competition with the Europeans. We called that option the *Halley Intercept Mission* (*HIM*). Then we thought of a completely spectacular "upstage" of all the Halley options by using the canisters to get a sample of Halley. Hilariously, we termed that option the *Halley Earth Return* (*HER*). So, we had *HIM [*Halley Intercept Mission] and then *HER* [Halley Earth Return]. We had to keep our sense of humor. (chuckling).

NIEBUR: Oh, I have seen references to that, okay.

ATKINS: You remember that?

NIEBUR: Yeah.

ATKINS: So, my "swan song" in the comet business before going off to manage power systems was studying *HER*. It was sad that, for an opportunity that comes only once every 76 years (Halley's orbital period), our nation, that'd won the "space race" to the Moon over the Soviets, wouldn't "wow" the world again. We opted out.

NIEBUR: Innovative idea, though, ready to go, yeah.

ATKINS: But back to Discovery and thinking about an asteroid return. So now, I found myself over on this Discovery thing with Frazier Finale. In fact, what we wanted to do was to come down close to the asteroid surface, but not land. We wanted to avoid having to solve the "landing problem." That would have been way "too new," risky, and thus probably disqualifying. That was the big bugaboo. But I thought if we could get close enough to the surface, I could employ another idea I'd had way back when I'd been doing electric propulsion. That involved rendezvousing with a comet and shooting sticky strings across the comet, virtually "laying" them on the surface, then dragging them back to the spacecraft, reeling them in with the dirt in that way.

So, we put some ideas like that into the *ASTER* proposal. Another was where you might even shoot grappling hooks and hold yourself close to the asteroid and things like that. This was, of course, way before Bob Farquhar and the *NEAR* team innovatively ended their successful Discovery mission by settling the spacecraft softly down on the asteroid's surface as its final resting place. That was so cool!!

Well, *ASTER* acquainted me with the Discovery program, but it didn't make it into the final 3 options in this Discovery *4* down select. Finale went away to await the next proposal

opportunity. But, during that proposal, because of the need for optical navigation to get that close to the asteroid, I'd included Tom Duxbury on our *ASTER* team. I remembered that Tom was a pioneer, if not the inventor, of that kind of optical, on-board navigation.

But even though they didn't select *ASTER,* they did down-select from 24 proposals to three "finalists" for the Discovery *4* mission; Stardust with Don Brownlee as PI, *Venus Multi Probe* with Willis Meeks and one called *Seuss-Urey*, with Firouz Naderi as the proposal managers.

There was a proposal manager on Stardust who was a JPL scientist type. I won't bother with his name because of what happened during the period where they were preparing for the "down-select" to the winner. The industrial partner for two of the finalists was LMA (Lockheed Martin) on *Seuss-Urey* and Stardust. I don't recall the industrial partner on *Venus Multi Probe*. Something happened between *Seuss-Urey* and Stardust, in the actions between the project managers and the Lockheed Martin team. The Stardust JPL proposal manager fell out of favor with LMA. So, the PI and the Discovery Office needed to replace him. This was a serious change, because the Discovery *Program* paradigm was that the proposal manager assigned by the institution providing the overall project management would be automatically the Project Manager for the approved project.

The Discovery program manager at the Jet Propulsion Laboratory at that time was Eck Davis. Ek was a brigadier general in the USAF reserve and had been a project manager of, I believe, *Galileo*. He'd also been a manager of *Voyager*. So he was a bona fide flagship manager and knew the space program and JPL's management approaches very well. He was well thought of around here and at NASA. So, he was the Discovery program manager.

One day, I got a call from Ek saying, "I'd like to talk to you. You've been involved in comets, and I want to talk to you about it." So, I went up to meet with Eck. And he told me, "We're going to have to make a change out on one of these Discovery missions." He described Stardust a mission to collect dust from a comet and bring it back to Earth. "You did a lot of considering this kind of mission when you were doing *Halley*. You understand something about this. We'd really like to have you come aboard and lead this proposal in the final competition."

Only a few months before I got that call, which was in '95, and after I'd spent 8 years in power systems, the JPL Division which housed my section reorganized. As part of this, my Division Manager met with me noting, "Ken you've done power for eight years. I would like you to come over and manage the Command and Data Handling Section." I felt this was an opportunity to expand my skills to a different technological regime—digital electronics. The challenge was that I would be an "outsider" to the folks there who were familiar with me as "the power guy."

In fact, one of the gurus in data handling was Don Johnson, a "guru" who knew everything about digital design, knew everything about flight computers.

The Division set up a meeting with the section personnel to introduce me as the new boss. After the Division manager did the intro and told them why he was moving me in, etc., he asked if anyone had questions. Don, raised his hand and said, "I've got one question for you, Ken?" I said, "Great, what's that?" He said, "Can you spell digital?" I really don't remember my answer—certainly I could spell "digital." I knew his message was that he was dubious of my technical understanding of the new organization. I recall trying to make a response that showed I knew I was the "new guy" and would need his help if I was to make myself an asset. I admitted my technical challenge, but I knew he knew I had management skill.

So anyway, I had been working a short while in the new section and in fact was deep in the issue of supplying the "attitude and information management (AIM)" subsystem to *Mars Pathfinder*. This involved working with a long-time friend of mine, Tony Spear. The reason I'm bringing this up is because it's important relative to how I was able prepare Stardust and the team for the "down-select" review that ended up designating Stardust as Discovery *4*. Tony [and *Mars Pathfinder*] had been put in as the first Discovery project as a "directed" thing before this down select.

NIEBUR: *NEAR*, actually.

ATKINS: *NEAR*. No, it wasn't *NEAR*. It was the one before that

NIEBUR: *NEAR* and *Mars Pathfinder* were first, and then *Lunar Prospector* was afterward.

ATKINS: *Lunar Prospector*'s the one I'm forgetting. Okay. *NEAR* was in there and *Lunar Prospector* along with *Pathfinder*. Okay. And Tony was *Pathfinder*.

Anyway, Tony had been, way back in the early days, when I was working on *Halley*, involved in some of the advanced missions like Venus Orbiter with Imaging Radar (VOIR) that eventually became *Magellan,* so, we'd known each other for a long time. Anyway, that transition had been made, and, with the reorganization, I was still in the division, but going in a little bit different direction than power systems. The Discovery stuff with *ASTER* was all additional duty. So, my future career and everything was in flux.

And then, I get this call from Ek that he wants to make life just three times more complicated. I was conflicted I needed some advice. I went to the Assistant Laboratory Director (ALD) of Engineering. He was my boss's boss. He owned all the division managers. It's all the people, all the personnel. Leslie Livesay is the manager over there now. Back then, it was John Gates and I had known him a long time. He'd been my Section Manager when I'd been in the Advanced Projects Group.

I went in there and said, "I'm really conflicted about this. Ek wants me to do this thing for Stardust." (In fact, I had told Ek when he first called me, "Why don't you go get [Ronald] Draper?" (Draper was the deputy on *Cassini*). I said, "He did the *Comet Rendezvous, Asteroid Flyby* (*CRAF*) study. (*CRAF* eventually became *Cassini*.)" I said, "He knows all about these comet missions." Ek said, "We've already tried that and he's not—they won't let him off [*Cassini*]. He doesn't want to do it. He's happy with what he's doing."

NIEBUR: He was busy.

ATKINS: He was busy. And so, [aside] the reason I'm stopping—you see that gentleman walking over there?

NIEBUR: Yeah.

ATKINS: I think that's Ray Newburn.

NIEBUR: Is it really?

ATKINS: Yeah. He walks like Ray. I'll find out. But anyway, Ray Newburn has a role in all this at Stardust. He was the guy with the comet models.

Anyway, back to the business of how I ended up on this thing - so, I went to Dr. Gates and I said, "I've got this job in the division and everything's going on well and now here's this project thing." He says, "Well, Ken, you've been in the line (divisions) for a long time. Maybe you ought to get a project stripe on your shirt. You haven't really done that." So, I said, "Aye, aye, sir." I went back and told Ek that I would do the proposal lead for Stardust. Well then, he had to get the PI, Don Brownlee and the Deputy PI, Peter Tsou, who had had the idea about this whole thing on Stardust, to OK me. Tsou had the idea of using this miraculous material "aerogel" as a "catcher's mitt" to capture the comet particles safely, that is, IF you had a comet you could fly by at a "slow enough" speed, say 13,000 mph! That's about 6 times the speed of a rifle bullet! "Aerogel" is an open-structured glass foam. It's 99% empty space, so it weighs almost nothing. But, being a foam, it's able to slow a high-speed particle quickly, as it passes through it, stopping it quickly without catastrophic damage. He'd come in with this idea late in getting it considered in the first batch of proposals. It was a real long-shot that it had made it into the final three.

NIEBUR: It was late? I didn't know that.

ATKINS: Yeah, there were originally I think, 23 proposals already in the pool. Somehow, they got to Charles [Elachi], and Ek said, "Well, yeah, put this in at the last minute because it's really a pretty neat idea—catching a comet sample and getting it back to Earth." And so, now I had to have an OK from Don and Peter I had known both of them from working on the *Halley* proposal.

Peter, I don't think was originally a science type. He was always interested in small bodies and sample return, sort of a science gadfly. He just loved that kind of stuff. And he was always out there bothering people. He's a very different. Anyway he came over and talked to me about it and said how much he and Don would like for me to do this job and so on. And I said, "Well, okay, I've already talked to Ek and so we made this agreement to do the thing." Peter was the guy that was supposed to be able to provide the aerogel.

NIEBUR: Right. You say supposed.

ATKINS: Right.

NIEBUR: Okay. I'll come back to that.

ATKINS: I started out on the Stardust trail and didn't know the first thing about how to catch up and win against *Venus Multi-Probe* and *Suess-Urey*. But, Lockheed Martin, in particular, Ben Clark, a leading LMA scientist, and Joe Vellinga (one of their senior engineering mangers), had been working on this with my predecessor. So, they had a rough draft of a project implementation plan and some starting answers to the question: "What's your 'win plan'? How are you going to do this?" And we had until October 23, 1995, the presentation date to the NASA Selection Committee, to get all the answers. I was to start with a "kick-off" immersion and take-over meeting at LMA on June 23. We had just under 4 months left to find the winning proposal and present it. It was a load of stress, but I'd seen stress many times before. Still, I felt far behind relative to Firouz and *Seuss-Urey* and Willis and *Venus Multi-probe*.

NIEBUR: And the whole program was new. Nobody—.

ATKINS: And the whole program—nobody—yeah, nobody had much [experience]. But you couldn't talk to any of the other people. And if they had gotten people already on board their proposal team, well, you couldn't interact with them.

NIEBUR: Did you have trouble finding staff for your team since you already had two teams going here, and *Pathfinder* was active?

ATKINS: Well, these were proposal teams, so they were kind of—.

NIEBUR: Lean?

ATKINS: Really, really lean but not too isolated. They were separated to some extent. JPL really didn't have any real formal structure for supporting proposal developments at that time for this kind of competition. There were no guidelines, templates etc., that all came later. So anyway, I got sort of desperate. And I don't remember who came up with the idea, but I went to Tony, called Tony Spear up and I said, I need help in pulling together a winning proposal. In fact, I needed help in getting any proposal together from a JPL standpoint. And he said, "Come see me."

I went over and I talked to him and we talked right through it. He had the Project Plan that he'd done for *Pathfinder* and he'd been through the gauntlet with it and it had been beaten

around and it was a thing that Headquarters liked. And Mike Ebersole was Tony's deputy at the time, had been his proposal guy, and had put together his project plan, which was a thick notebook with management, implementation, and mission and everything all in there. And, salivating, I thought, "Wow! Here's the thing." And so, he said, "I tell you what I'm going to do. I'm going to let Mike help you. He'll take our plan as a model and rework it for your project. We'll put the Stardust stuff in there and you get your guy, Bill Edmiston (a document support man that was already on Stardust when I came aboard), to bring the mission stuff from Chen Wan Yen, and we'll put it together for you." Incredulous, I said, "How come you would do this for me?" He said, "Well, you're the only one who's been smart enough to ask for our help." He was implying a "miff" because they should have recognized and exploited his experience. He felt wrongly ignored by the following Discovery proposers. I was amazed and relieved. I wasn't so smart, just desperate.

NIEBUR: You're kidding.

ATKINS: No. You're the only one who—

NIEBUR: And that's all it took.

ATKINS: The only one who asked him for help was me. And so, I got Ebersole working with what was there and what he had from *Pathfinder*. Now I suddenly felt I had a "leg up" and I could get this thing going with a real potential to win!

And then, I experienced another real coup. I inherited a 'crackerjack" lady for the "Outreach and Opportunity" part of the proposal. This came when I came to the consideration that outreach was 10 percent of the scoring scale the NASA Committee would use to select the winner.

NIEBUR: Right. That's huge.

ATKINS: Her name was Collins, Katherine Collins. And she had done background in public relations and so forth. And so, I had her, I had Bill Edmiston, and now I had Ebersole. And then, from the mission standpoint, looking at the Mission Plan and the Operations Plan, bingo, I thought of Tom Duxbury. He came in my mind right from our *ASTER* association. He was doing some Mars science things but I was able to loop him back in part-time for Stardust. And so, I was cobbling together a JPL team to match up with the LMA spacecraft piece of the action. In the cost area, I had Lee Rosenberg, who had been doing it for a number of different projects. He started looking at the Stardust cost to build a rationale as to why this was affordable.

Anyway, we roll on towards the battle to end up winning in October. And I was thinking about, how can I find the edge, where do I get an edge? One day, it was raining like crazy. JPL often has interesting seminars at lunch. And this day, Bob Ballard who had discovered the wreck of the cruise ship *Titanic* on the bottom of the ocean floor not too long before was giving a lecture.

I wasn't doing anything special for lunch. I often went running, but it was raining hard. The topic intrigued me so I went over to his lecture. As part of his really interesting talk he described how they had put together a student outreach network. They called it *JASON*. They interfaced with a satellite over their ship that controlled the underwater deep robot explorer. The satellite

then hooked up the network with students they took out on the ship who, in turn, interfaced with schools around the country (and world) with special communication technology. It was incredible.

So, I saw an already-existing infrastructure that Stardust might exploit. How about if I made a deal with those folks where we use their *JASON* structure for interaction with the schools and made a partnership where we could involve them in the comet mission? I was going to use a communication network that linked school kids all over the country to the bottom of the ocean to now link them to a mission in deep space! I also talked to our PI, Don Brownlee about this crazy idea. And he said, "You know, comet dust is always falling on Earth from space. It drifts down from the ocean surface and settles in the mud at the bottom." And he says, "This is a natural relationship between us and JASON linked by comet dust. This will work fine. We can do some neat things with students regarding searching for interplanetary/comet dust particles in the mud from the ocean floor."

Through Katherine, we made contact with JASON and easily succeeded in enlisting them as a member of our team. She had already been working with the *Challenger* Center (a space-oriented learning program dedicated to the memory of the shuttle *Challenger* crew), and we had a third leg through LMA's Ben Clark who had put into the proposal an involvement with a museum in his home state of Oklahoma: Omniplex. So, we had a magnificent three-pronged structure in the outreach area that was innovative and unique. I knew I now had a real plus in our outreach element.

I also had picked up from Spear some ideas and thoughts about implementing a project for quick and efficient scheduling; "concurrent engineering" became another potential discriminator for Stardust that the other contenders might not understand or emphasize.

NIEBUR: Okay. Like parallel pathways?

ATKINS: Parallel pathways of development. I experienced a déjà vu moment! Spear jogged my memory about how General Bernard Schriever had structured the *Minuteman* ICBM development in the early 1950s. He invented the approach for independently developing pieces of a complex project and then, with careful interface control, bringing them all together successfully in a "system integration" activity later in the schedule. It was systems engineering in parallel time-saving paths. This allowed us to close what was then believed to be a "missile gap" with the Soviets. It became the paradigm for the emergent aerospace industry. But over the years many companies had lost focus on it and run into trouble implementing it without the crisp discipline of leaders like General Schriever. Without full commitment across a project, or if you have any real communication problems you can really stumble in its use. For instance, today's news notes Boeings trouble with the 787 *Dreamliner* now in development. The situation is that with major elements of the airplane "outsourced" to foreign manufacturers problems emerged because people there speak a different language and have different work cultures. Small misunderstandings easily ruin interfaces in manufacturing. And when it gets to the integration event on the schedule, the door won't open right on the baggage compartment, or whatever it might be, because it didn't all fit. This forces costly "do-overs."

So, concurrent engineering became another 'edge' for me. I would propose using parallel test beds to test early and often, aiming for eventual success in the central mission test bed. Spear was doing, this kind of thing, sort of a "continual" end-to-end testing regimen. I would put

things in there early and test end-to-end from start to finish. And then, I brought this to Lockheed Martin.

Well, their culture had drifted to mostly a more sequential model which to me left real check out of interfaces on key elements pretty far downstream in the schedule. They do preliminary design, detail design, and then build with element functional testing, but leaving real end-to-end interfacing to later. And so, I had to work through getting them to buy into this. I was successful in enlisting them to showcase this approach as a discriminator for Stardust in comparison with the other two. And they did in the proposal and selection phase, but they relapsed when the "real development guys" came aboard after we won. They did, but they didn't. From a proposal standpoint, we were putting together the charts and I had this "fishbone" chart where the different parts of the project would feed into different points but the central "backbone" kept a heavy focus on "end-to-end-all-the-time" consciousness; the "system integration" had to drive everything.

And so, the pay-off from this approach was you got down there in the schedule where it all had to work together, it was already really well integrated and tested at the interface level. In other words, you had the PI talking to the mission guy, talking to the propulsion guy, talking to the ground data system guys, all at the same time, all the time. With Tom Duxbury, my on-board optical navigation man, as the overall Mission Engineer I kept the focus on end-to-end data flow from the "git go." With *Mars Pathfinder* and *Mars Observer* already in the operations phase and John McNamee's (John was *Mars '98* PM) two *Mars '98* spacecraft in development at LMA just ahead of Stardust, the Mars program already had a mission operations system in existence. Following the JASON exploitation model of hitchhiking on an existing infrastructure, Tom proposed that we try and make a deal to simply "add a node" to the existing Mars operation

system thus avoiding an expensive "from scratch" development of a stand-alone Stardust ops system. We'd share in a multi-spacecraft operational pool thus drastically reducing our overall ops cost. This turned out to be another "wow" because using an existing system would not only be less cost, but also a big risk reducer.

NIEBUR: So, you're leveraging all over the place here. You're leveraging from *Pathfinder*'s proposal, from the *JASON* E/PO and now the Mars node. And so, you really are pulling it together in a way that was faithful to the faster, better, cheaper mode.

ATKINS: It was absolutely faithful. We went even further. As mentioned, the *Mars '98* program was in development, also at LMA, just ahead of us. Both *Seuss-Urey* and Stardust, being proposed with LMA as the industrial partner, planned to hitchhike on the subsystems design commonality with *Mars '98* wherever possible. That, in itself, wouldn't be a discriminator in the selection competition (except in comparison with *Venus Multi-probe* that had a different industrial partner), but by emphasizing my "concurrent engineering" discipline plan I could see another element of competitive advantage.

Also, Lee Rosenberg, a man with long experience with JPL project costs, was my cost guy at the time of the selection presentation. He did a great job of highlighting our cost consciousness. So, we go forward into the presentations to the NASA Selection Committee feeling some confidence of winning. These were held at LMA in Denver. Stardust was on October 24-25, followed by *Suess-Urey* on 26-27, 1995.

One of the things that I had to deal with was that I didn't have any project experience from the standpoint of being IN as a member of its line of authority. I was a "line" manager that

had projects as my customers. Still, I put that in there and claimed that I'd managed two Sections that were the deliverers of two key flight subsystems, Power and Command and Data. Also, I had a great background in mission design and analysis. However, that wasn't the same as having a project job like being a mission operations engineering (MO&E) manager, project manager, or a systems engineering manager. I'd always been in the line supplying stuff. And so, I had to try to make a case as to why my experience was okay.

NIEBUR: What'd you say?

ATKINS: Well, I said some of what I just went through. I said, I had to have organizational skills. I managed the delivery of the *Pathfinder* AIM and the *Galileo* and *Cassini* power systems. I just stuck to this long delivery experience base. I said I think I had good interpersonal skills and had dealt with people from the standpoint of this. I had read *Five Pillars of TQM* by General [Bill] Creech and applied those principles to my management style.

NIEBUR: Yeah. Oh, I remember that era, sure.

ATKINS: Yeah, okay. And in fact, I always carried, and still have in my daily journal, a summary listing of "action values" from Creech's book—let me find it here in—(looks in zippered journal)—yeah, here it is. Leadership.

NIEBUR: And you've got the list of 25 right here starting with speak the language of trust, not of mistrust.

ATKINS: Yeah, right, okay. And so, I was talking about these kinds of things. And I had pulled this out.

NIEBUR: Can I just read this one line? Courage, confidence, savvy, materials.

ATKINS: Maturity.

NIEBUR: Maturity.

ATKINS: Integrity, and desire or passion, okay?

ATKINS: And one that was really special to me has to do with "listening." I went back to this list and this one many, many times during the Stardust development and flight. It says, "Listen for the echoes to learn if it's all getting through." In fact, most of the list is about communicating directly and sincerely.

NIEBUR: Yeah, number ten.

ATKINS: Yeah, you can see I have it checked. And so, these things were things I said. I tried to weave into a picture of what leadership was. Anyway, I made an attempt.

Then, we made our presentations. And in the science area, there was a set of de-scopes that I had put down relative to—because they wanted to know how you're going to stay inside

(the cost cap)—because if you get 10 percent out, the Discovery Program rule called for a "Cancellation Review" and you're basically dead. And they were serious. Mark Saunders was the program manager back at Headquarters and he was very—he was (strong) on this. He'd been one of the nuclear submarine guys and had the discipline and integrity instilled by Admiral Rickover for all navy nuclear ship officers.

NIEBUR: He's tough.

ATKINS: He's tough. Anyway, I was weak on my presentation of the "de-scopes." Apparently, the other competing proposers were too, because after all three were completed, the Selection Committee convened a set of "Delta Reviews" that they held the next week at hotel near LAX relative to the importance of comet science versus—and why was it so important—and to look at the priority of science requirements relative to the scope. Here, again I think we turned up an "ace." Prof. Jerry [Gerald J.] Wasserberg, who was a Dean at Caltech, had been a comet scientist for a long time and had a lot of prestige with NASA and the Academy of Science. He shows up over there supporting our PI, Don Brownlee, and his science team. It was all about just the science piece. And they were looking at each team on this issue. So, they went through that. And we came out of there feeling like we did pretty well, particularly with Wasserberg there. He'd been very powerful in his argument for Stardust.

NIEBUR: Oh, no question, no question.

ATKINS: And so, we went away from that meeting feeling kind of good. Well then, I went back to my day job, after I'd gone through that. And what was it that came up? Martin.

NIEBUR: Jim?

ATKINS: Jim Martin was the chair of the selection review board (NASA Committee), and he had grilled me pretty heavily putting me in the proverbial "deer in the headlights" position regarding the potential for science de-scoping when he asked me, "Well, what's your de-scope plan?" And I really didn't have one.

NIEBUR: You didn't have one?

ATKINS: Didn't have one at that juncture that was very good at all. And so, I sort of stumbled through that. And the hot flash of the "deer in the headlights" happened and I felt that warm feeling. Anyway, after that was over, I thought, "Well, I've lost it because I didn't have a crisp de-scope plan." When I sat back down, the LMA New Business Manager, Cindy Falconer, leaned over and whispered, "You guys were doing so well! How are you going to get the momentum back?" I thought, "What the heck can I do, dance?" This reinforced my fear that I'd blown the whole selection. However, my mood recovered as the following presenters did actually regain the momentum. By the end of the second morning, we were finished and I was in pretty high spirits.

Well anyway, right after the lunch hour, we were tidying up the presentation room and preparing to head for the airport. Just before heading out, Brownlee, Ben Clark, Vellinga and a

few guys from LMA were spending a few minutes talking about the day before. And Jim Martin (the Selection Chairman) comes in the room and joined us.

He didn't say anything about the management or de-scope thing, but when we were talking, Jim said, "You know, I always really liked comets." Just like that, and then he left. So, I was thinking, well, okay, that's good. And one of the other guys, I can't remember who, maybe it was Ben, said, "Boy, that was an interesting comment, wasn't it?"

Anyway, we'd finished! The Selection Committee and the process had to now vote, or whatever. For our proposal team, it was "let down time" and back to the day job. I no longer had any team now. Everybody's gone back to their day job. I had—.

NIEBUR: Right, because there was no funding.

ATKINS: Yeah, no funding. We had a certain amount to do the preparations and the selection review. That was now gone. I'd had some staffing ideas about the "What if?" in case we won and so on, but nothing was nailed in concrete. I recall an incident that happened during all the rush and press to get the updated proposals in to NASA as we were all getting ready for the selection briefings. One day, after we'd supposedly put our stuff in the mail, I got a call from Willis Meeks, and he says, "I don't know how Headquarters did this, but somehow or other, when they mailed out these proposals or when the proposals were being mailed back or whatever, "I got yours, too. I just want you to know this has happened, but I've protected the sealed envelope. We haven't opened it."

NIEBUR: Oh, my. The results, the comments?

ATKINS: Well, no, it wasn't the results.

NIEBUR: It was the proposal itself.

ATKINS: It was just the proposal that was going into NASA before the Selection Review. I don't remember how long before, but not long. Anyway, it would have been a terrible breach at the time in terms of the competition. So, that was worked out in an honorable way and I felt, boy, that's great. So, everything was cool. There was camaraderie and integrity between the competing teams. I recall that after we'd tidied up after our presentations, we knew the *Suess-Urey* Team would be in there the next morning. And we wrote on the board as we left that day: "Good luck, *Seuss-Urey*." Firouz (their JPL PM leader) later said, "It was great when we came in there and saw that on the board you guys had written that. It was appreciated." So, we were back to the day job.

NIEBUR: It wasn't a brutal competition? I mean, it was all the same institutions, I suppose.

ATKINS: Yeah, it wasn't as brutal and battering to me because it didn't have the time that the *Halley* thing between solar sail and ion drive did. By the way—just a side note—remember I mentioned the "pins" Friedman had for the Solar Sail option. His "motto" on the pin was "I'm a solar sailor." I recall my team's was "Truckin' with Ion Drive." (Chuckle)

Anyway, just a month after the presentation in Denver, in fact on November 22, the day before Thanksgiving, the phone rang and it was Ben Clark and Kurt Bassett (Head of LMA New

Business). ”Congratulations!! Stardust is the winner!!” I almost went into shock—knees felt weak—we shared some thoughts and they said Brownlee would be calling me immediately. His call also showed his surprise and delight. We congratulated ourselves.

NIEBUR: Awesome. Now, how did he know? How did he get the call first?

ATKINS: Well, I recall that NASA, (Mark Saunders and Jurgen Rahe) had called him early in the a.m. I was then flooded with calls—got messages from Firouz and Willis, from Charles Elachi—and I began notifying others. Set up to meet later with the JPL Stardust team. I then went through a day I’ll never forget.

NIEBUR: And then, Don called Ben first.

ATKINS: Don must have either called Ben right away or whatever. And then, it was get the word to Ken, or something, and I got the word. Well then, here's this hot flash feeling again, because now you’re back and thinking, “Oh, that's out of the way. And now, you've got this thing wrapped around your axle that you have signed up to be the manager of, and it has actually been selected.” Well, okay. Then, were going to have the out brief later. So now, I was all excited. I was going to be the project manager of this Discovery project. So, I was thinking, “Oh, this is great.” People were excited about it. The Lab was excited. Stardust was selected. So, I was this “big man on campus” sort of felt the “celebrity.” However, the truly unforgettable

thing about this day involved General Ek Davis, our original JPL Discovery program manager. I don't think I've previously told you what happened with him.

It wasn't long after he'd named me as the new Stardust proposal manager, that he was diagnosed with lung cancer. He'd been a heavy smoker and was given only a 10% survival probability. As the activities and preparations for the Selection Reviews ramped up, Ek was sinking. Soon it just took him out of the daily capability and John Beckman picked up the baton. John was working for Charles Elachi in developing other space project options and stepped in to pick up for Ek as an additional duty. By the time NASA announced that Stardust was selected as Discovery *4,* he was close to death. On this day of triumph I immediately thought of the times he and I had met as he recruited me for Stardust. I wanted him to share in excitement getting this new Discovery project for JPL. The Public Affairs Office called me regarding requests for interviews from local news organizations that had been alerted to the announcement by Press Release. I told them where I was going and why.

NIEBUR: That's good of you.

ATKINS: And so, I went to his house and sat with him and told him. We had a good talk even though, even on full oxygen, he was coughing and short of breath. While there, the *Pasadena Star News* called the house because I'd left my whereabouts with my JPL secretary. And so, I was able to do that interview while Ek was able to listen there in his wheelchair. And so, anyway, that was really very poignant. I was really blessed by this experience. And I think I was about the last JPLer to talk to him because the next day, he was gone.

NIEBUR: The next day?

ATKINS: No, I was there on Wednesday, November 22 the day before Thanksgiving. I got the call from Beckman on Saturday that he'd passed away on Friday, the 24th. But he was excited. I'm sure it picked him up a little. I could observe that in his eyes. It was a really—he was tough. It was hard to lose such a great man, but it was satisfying that he knew that he'd succeeded in leading JPL to getting one of these things, because of all the other institutions that were in there at first. And certainly, the *Venus Multi-probe* was a finalist. It would have been under another institution.

NIEBUR: I'm glad you got to tell him.

ATKINS: I am too. It was a "bittersweet" part of the day. It was one of those things. And then, two weeks later, Mark [Saunders] comes here to do the out-briefs. And so, we meet down here in a conference room and he goes through and he says, "Okay, you guys, here's the gist of how the selection came out." Brownlee was down from U of Washington, we were all sitting at a table with Mark telling us what happened. He goes through each of the elements.

And he says, "In Management, *Seuss-Urey* was stronger than you guys. In Science, you guys were stronger than *Seuss-Urey*. In Spacecraft and Integration, the industrial partner factor—with LMA doing both, it was basically a toss- up. So we had a virtually a 'dead heat' on those three evaluation factors. But there was a significant difference in the Outreach factor. Stardust was definitely stronger in the Outreach component. So, the deciding factor in this was Outreach. That's what decided it."

NIEBUR: Wow. Wow. I bet you felt really good about making the *JASON* outreach.

ATKINS: Yeah, the Outreach program had been the difference. And we had also had a small and minority-owned business involvement that Lockheed Martin had arranged with some Native American group in Arizona. So, that was in there, too, but I'm sure they would have done the same if *Suess-Urey* been selected.

NIEBUR: Nicely done.

ATKINS: Okay. So, we won. "But," he said. There's always a "But." "But we recommend—" or "But we think—" I don't remember exactly what the words were, "we think that your project manager doesn't have the required experience to do this and you should consider getting more experience there." This is to Brownlee. So, I'm thinking, "All this is over. I went through a tough gestation and labor, but they won't let me have the baby!" What a bummer. So, as we walk out of there, I said to Don "Well, I guess that means you'd better find yourself another project manager." And he says, "Wow, I don't know what that was all about." Everything was now uncertain for me. Well, Charles [Elachi] was the guy over the program after Ek had died. He'd, of course, brought John Beckman in. I don't know if you've heard of John.

NIEBUR: I've heard of him. I didn't know.

ATKINS: John was, as I mentioned, acting as Discovery manager. Well, John and I had grown up in the Advanced Projects Group and had been friends from the very early days. I'd been his boss and now he was mine. He was the manager of the Systems Division (31) at this time, as well as being the guy up there working part-time for Charles, but, on some classified activities that I'm not totally aware of. I knew I had support there, but how could he go against the recommendation of the NASA Committee. He couldn't. I found out later that LMA had been impressed with what I'd done and came to bat for me. I'm sure Don and Ben Clark were strong supporters. And I think Noel Hinners, who was LMA's VP, made a commitment that LMA would help me succeed.

NIEBUR: Okay. Sure.

NIEBUR: I had no idea that they had that kind of power or influence.

ATKINS: I don't know exactly whether they did or not, but somehow or another, I kind of feel that Lockheed Martin stood up for me. And I think it was because of relationship that had built up during the proposal activity.

NIEBUR: And they liked your philosophy, your approach.

ATKINS: They certainly did that.

NIEBUR: Great.

ATKINS: Anyway, I was appointed to stay on. We'll talk about the staffing in a moment. But part of the Mission Definition and Requirements Agreement (MDRA or "4-Party Agreement) that now I think they call the Project Plan, which is "the deal," was written by Mark (Saunders) relative to what was going to be done. And in that MDRA, you had to have your staffing. You had to have your cost in there that was going to be held to. This was the thing that they were going to kill you with, if you broke the cost cap.

Mark had included the definition of an incentive contract with LMA defining a certain per-cent based fee sharing vs. reserves line. That was an important element that involved LMA being masters of their own fate because if you meet the milestones and you operate in a certain way, you earn your full fee, but if you're falling behind and you have to require reserves because of poor performance (e.g. not meeting schedule, quality, etc.), your fee goes down in proportions to how far you're getting in trouble.

NIEBUR: Was that standard practice at the time?

ATKINS: No, no, it wasn't. It was always "cost plus" or some other type like "award fee." And I'd managed an award fee contract for the Galileo power subsystem as the section manager. On that, I had to go to Xerox, our contractor, at different intervals and then do award fee determination. I was the guy that had to grade them. That was terrible because I could see they had no incentive to always tell me the truth.

NIEBUR: Okay, that's an excellent point, yeah.

ATKINS: Right, if I downgrade them, they'll lose money, and they'd have an angry boss. I've been against award fees since I had to be an award fee adjudicator in the line.

So, I strongly supported the incentive fee structure. It made them responsible for their success or failure on the share line as facts showed the performance in an earned value management system, which Mark forced on the project anyway. He said, "You will use an EVM system." Well, I didn't know the first thing about EVM. It was all novel.

Now, I knew the military used earned value, etc., but I understood it to be very cumbersome and had a reputation of complexity and bureaucracy without much utility. The structure was complex enough to make the result available after a period to take and process the information. Folks said it was old news by the time they got the result; like looking in a rear-view mirror. Discovery was to be faster, better, cheaper. You are not going to do that and be consistent or practical with EVM, I thought.

NIEBUR: I'm surprised to hear you say that they layered it on top that early. I didn't realize that Stardust used it.

ATKINS: Yeah, it was in—.

NIEBUR: It was new to the lab?

ATKINS: We were the first to do it (at JPL), yes. It was new to the Lab. The Lab didn't do things this way. We did award fee or cost-plus contracts in our "flagship mission" culture. And although Tony (*Pathfinder)* was a Discovery mission, I think they used cost plus contracts. They just, you know, they were winging "FBC" in going through that. They were trying to figure it out. They cut "red tape" and changed the support approach with the line organizations. And then, they had this review board that probably filled up the mall (very large) that Tony had to deal with.

So, we had those imposed requirements to worry about, and we planned our launch on the 7326, which is a Delta rocket with three solids. And we were focusing on high design heritage from *Pathfinder* and *Mars '98*. So, phase B was going to be interesting when we considered the "cash flow" issues, such as "long lead" items and schedules. Then, that brings me to the staffing and to a couple of things that happened – I'll try to walk through this pretty quickly here.

We now had this job (project). I'm feeling a bit "persona non-qualified" from my PM confirmation trials. Now the involved institutions, JPL and LMA, had to get the project back on the rails. The proposal team had "fragmented" back to other work. (Consulting his calendar history). There was a scheduled Stardust debrief to JPL management, which was December 9th. Yeah. *Galileo*'s Jupiter orbit insertion [JOI] was right there, and I had been called before the senior staff. I was going to get to talk to the JPL Executive Committee (EC) this day on Stardust because we'd just been selected and top brass wanted an introduction to what kind of animal we'd just brought home. But JOI (*Galileo*'s Jupiter Orbit Insertion event) was being done that afternoon. So, I was in a room upstairs waiting to go to the EC meeting. We were watching the flight ops activity on the TV monitor in the room while they were waiting for the radio signal

from *Galileo*. And Sagan comes walking in there and he's in the room. We're all in there watching JOI be successful at that time. Okay.

My point is that I was really feeling the anxiety of being responsible for something that was highly visible and important to the Lab, and I was facing restarting the Stardust activity as a real project. It was no longer a proposal. Top management was putting me in a spotlight. I had the plan (on paper) and JPL/LMA commitment. Now I had to start crisping up the details, start staffing and organizing, and most of all get the money flow set up to pay for it all. It was daunting, yet exhilarating.

We had a Phase B activity to complete culminating in a Confirmation Review/Briefing with Wes Huntress (AA for Space Science) in the next October (1996). One of the things that was brand new and that nobody had ever done before in a FBC project was trying to figure out how you really do design-to-cost and manage-to budget, particularly if you've got a thing like an acquisition contract that's incentive based, attempting a new way to do EVM under the FBC constraint, and so on. Time suddenly felt really short.

So I was really squirreling around big time. I needed help. I started trying to find a project systems engineer. I was trying to find a business manager. I had my outreach person. She was already aboard. You could not have a deputy project manager.

NIEBUR: Why?

ATKINS: Goldin and his advisers (NASA staff) had looked at past projects that had problems with cost and schedule, and because of some of the things that had happened before, they decided a contributing factor was too many managers.

NIEBUR: Really?

ATKINS: Yes. So, there was basically a culture at that time at NASA by Dan Goldin that you want workers, you don't want managers. He had too many managers at Headquarters, as far as he was concerned.

NIEBUR: Oh, yeah, I remember what he did with them, yeah.

ATKINS: Okay. So, he said no managers. So, I could not have a deputy manager on my org chart.

NIEBUR: Makes it kind of hard to do things like succession planning and doling out responsibilities and such.

ATKINS: And it was. I could have a Project Engineer, though. Considering the overall organization, I'd worked it in the proposal activity and had developed a logic in my mind for a simple structure by thinking, "Look, I don't want to write zillions of checks." I had experienced feeling I had too many staff reporting to me during my Section Manager days. I only want a few checks (allocate money) to write to the few folks responsible for a few different sub-elements. So, we'll have spacecraft flight system. That'll be Lockheed Martin. We'll have mission. That'll be Tom Duxbury. By now, I had picked Tom Duxbury to come over and do this

now because he had that optical navigation experience. But he wasn't part of the "mission people" line organization. He was outside that culture. He was over in the "science" division.

NIEBUR: Oh, I didn't realize that at the time. Okay.

ATKINS: Right away, they're (the mission design organization) going to say (that's our charter) you should be picking a mission person, not a science person to do that. And Tom was not. I had to work that out. I wanted then also to have the check for the science team. That worked out to three main flows of money to get work done: science, mission design and flight system, okay. So, those were three areas. I'd keep management functions. And then, there was the *JASON* satellite-to-seafloor project (Outreach). Anyway, I tried to divide it up into as few things as I could. And then, I had to get these people aboard. (looks in folder) I don't think this has it. (offers a paper) It doesn't have my org chart, but I do have it at home if you ever need it. This is a paper I wrote to capture and summarize how we implemented cost containment and risk management on the project.

NIEBUR: [A paper titled] *How to plan and manage reserves effectively*.

ATKINS: Yeah.

NIEBUR: Awesome.

ATKINS: That I can provide you electronically if you like.

NIEBUR: That's lovely. Thank you.

ATKINS: So, trying to get the people that would be in charge matched into those three "cost buckets" was the way I wanted to do it. And I drew a picture of the project [with Management] in the center with the all the different elements around it and assigned them [drew a 'loop' around them] into the three areas and to validate against the organization chart that I hadn't forgotten functions for example, navigation should be under Mission Engineering & Ops. That's one of the checks that I write. Another is that the launch integration function would be under "Flight System" dah, dah, dah, and I went around and I had a circle of things that you had to do matched to each one of the three main responsible persons.

So, staffing. I started trying to interview people to be the person who would be the project engineer. I tried Matt Landano. He wasn't going to do it. He was still deep in the *Galileo* project. But Rick Grammier who had been my *Cassini* Command and Data Handling (CDH) system element manager (when I was Section Manager for that product) came to mind as a real great possibility. He was working for Gavin (*Cassini*) who was down at the Cape now, still on board that project. Rick was pretty much complete with his job on *Cassini,* so was available. I resolved to try for him.

Next, I called up Don [Brownlee]. I needed to discuss his role in the organization structure, I knew that there would be some battles between Science and Project Manager because there always are.

NIEBUR: That's fair.

ATKINS: Okay. We were both looking at my org chart. Don, as PI was at the top. I said, "Don, you know something? We would rather have a core of people above us can help us make sure that the Science-PM interaction goes well. So, on my org chart coming up here to project management, you, as PI are up here, okay, but you've delegated the project management to me in that case. Then, there's your science activity and you have that. So, you've got a role where you're the boss, and yet, also responsible for getting the aerogel developed and delivered, the Dust Flux Monitor (DFM) delivered by Tony [Tuzzolino, University of Chicago], the CIDA (Comet and Interstellar Dust Analyzer) from Jochen [Kissel, in Germany] and the science examinations, team meetings, reports, etc. You have a role that's analogous to a Playing Manager in baseball.

But, for adjudicating issues, I drew a stem out from his box above me but over to the side, and I called it Governing Board. If he or I had an issue we couldn't resolve at our level we'd call on the Governing Board to make the call.

We agreed to put the institutional signatories to the 4-Party Agreement in as the Governing Board. It was Charles [Elachi], who was the Director of all the Planetary missions at JPL. It was the PI, Don, who would Chair of it. It was Noel Hinners, Vice President of LMA, and Mark Saunders, the NASA Discovery program manager. That was the Governing [oversight] Board.

And then, I had another group that were people that I felt were "gurus" in key areas. This was a group I could turn to for mentoring and advice when I ran into problems. Tony Spear had now been successful under the FBC banner and had already helped me. Tom Gavin and I had been long time friends and he was my customer when I'd been a Section Manager. He was the

top engineer as Systems Manager on *Cassini*. I also had Joe Savino, a real technical expert in electronics/avionics and a great trouble-shooter. Joe was always called on when projects with electronic problems needed strong expertise. And so, I had those people.

Then I called up Tom and said I'd like to get Rick up here. He went through the process and said, "That's a pretty good idea." And so, he said, "Okay, here's the timeline to get him transferred over to Stardust." Then I talked to Rick who was excited about doing it. So, that all was okay.

When it came to getting Duxbury who was in the Science Division aboard as the MO&E Manager, I had a lot of problems. But, because I really emphasized his skill in optical nav and his experience in operations, I was able to get him. Joe Vellinga was the Lockheed Martin manager for the contract. He'd been superb during the proposal phase. This rounded out the primary technical team.

Then, I got a call one day. I still didn't have anyone selected on the earned value business operations. The call was from Bredt Martin who had been working for Jim Graf on *Quick Scat*, an earth orbiter aimed at measuring ocean features. He'd been doing earned value type things. He knew performance management, but I think he thought Stardust would be a more-exciting mission with a great opportunity to tailor EVM to an FBC project. He wanted to work on Stardust.

We talked and interviewed and talked to Graf and so on. And so, he came over. He really knew this stuff. He knew all about all the acronyms that you'll see in here—BCWP, BCWS—and all the details that accompany measuring earned value. [Showed Susan figures from paper]

NIEBUR: I've seen more than my share of those, I'm afraid.

ATKINS: Okay. And so, this is one performance metric. And these are two I thought were kind of key. Bredt knew EVM, but the Ralph Bartera doing the proposal work plans for doing EVM. He was an older man, but he was very good at schedules and a great mentor. He was also a JPL employee, while Bredt was a contractor. Bredt was young and innovative. Besides, I felt I needed all the help and depth I could get on this. It was mandated by the MDRA, it wasn't part of my culture, and I knew it was going to be very central to whether we could actually do "manage-to-budget" staying inside the cost cap. An analogy comes to mind from major league baseball. The Dodgers manager is Joe Torre and he has a similar situation on the crucial Left Fielder position. They have two extremely talented players there, Juan Pierre, (young, fast, but doesn't hit homers) and Manny Ramirez (a legendary hitter and home run king). They both have World Series rings from teams they played for. Juan Pierre's got a great batting average. You don't want to lose him. But you've got to take Manny; he brings electricity for the fans. Torre values them both and together they are dynamite for the Dodgers. So, I brought Bredt on board. And now, I had to work carefully in leadership to ensure they could work together as a team to bring real power to the cost management position. It turned out to be a great one. The result in controlling costs shows that.

With Bredt and Ralph we formed the Planning and Control Team to handle all the funding and scheduling elements. So, that was a stem line below me over here to the side. That was business management. Outreach was also stem line under me, and below I had the three biggies ($$) with the spacecraft, mission design and ops, and the aerogel and instruments.

So, that's how the staffing came together. And we had to prepare for this to sort of kick off. And to do that, I had—whoops, sorry.

NIEBUR: Oh, no, it's fine.

ATKINS: You'll see here an event called the CRR. [Referring again to the paper]

NIEBUR: Confirmation Readiness Review, right?

ATKINS: Well, that's not what I called it. That's maybe what people call it now. But, in order to make it really functionally appropriate, I called it a Capabilities versus Requirements Review (CRR).

NIEBUR: Oh, I like that.

ATKINS: The reason I did that is because there's a big difference between implementing a requirements-driven project where the requirements change and the cost floats out as a result. In the case of faster, better, cheaper (FBC), you're looking at capability driven. You've got existing designs and the cost is fixed. The budget becomes the key constraint and the project has to take what it can afford and see if that capability captures enough of the science requirements to make it worth doing. Controlling becomes a top priority. Otherwise, you get cancelled.

NIEBUR: You change the design and just keep the cost the same.

ATKINS: Yeah, change the design, or rather take a design you can afford and keep the cost fixed. That's why you must have a de-scope process. To get that, we needed to prioritize requirements. We "binned" them into three prioritized categories. We had a lot of discussion with Brownlee and his science team, saying to them, you've got have priorities because I've learned my lessons about de-scopes. There are elements we might have to give up.

NIEBUR: Yeah, it's huge, yeah.

ATKINS: And the people that wanted the camera [there are camera people because Voyager and everybody, took cameras for science]. Thus it's a science instrument, right? I said, "No, it is not a science instrument on this mission. It's there because it's necessary for optical, on-board approach navigation to get to the nucleus once we can see it from the spacecraft as we enter the dust cloud. That's why it's on there. We have to have it to get to the comet. Pictures for science purposes will be a "secondary objective." We're just going to use it to take some pictures while we're flying through because our "primary" job is to catch 1,000 particles."

So, we moved all the science "requirements" into these primary, secondary, and tertiary "bins" [priorities]. There was a big battle about all this because Peter [Deputy PI Tsou] wanted to have some kind of a collector on the—wanted to have some things on the particle collector mast to "actively" capture and store or analyze coma gases during the fly through. And so, the science team talk was all about that at many times.

And it used to be that the science team would meet every Thursday, I think, at JPL: Martha Hanner, Peter, Ray [Newburn] and some of the other science folks. They'd have

teleconferences with other science members around the country including Don and Ben Clark [LMA]. And then, it wasn't long after that, maybe Friday morning or the next day, I would get called with concerns. "Concern" became a big word - we're concerned we're not going to get the volatiles on here or whatever it was. It became a word I was tired of hearing. But it was one of those things you had to struggle through. The prioritization became a very valuable defense for the PM.

Anyway, back to the CRR. The reason I did it that way was because I knew that we were trying to do was not business as usual. It turns out you can't just look up a recipe for design-to-cost. It's easy to say, "design-to-cost." But nobody tells you how to do it. I tried to address it head-on asking, "How do I do this? What are the logical steps?" I started with a review of what we had and how much it would cost. And then, this paper, which I wrote afterwards in 2004 captures exactly how we did it.

NIEBUR: I'm so glad you have this.

ATKINS: What we did in the CRR, we took each of these subsystem elements—this one is an example in here [Chart from Paper]—and I had each subsystem manager, person in charge at Denver stand up in charts that answered three questions: What exists, what do I have? What modifications do you have to make? And what's brand new? In these three columns we could then follow with the key cost questions. How much will it cost? What is your schedule? And where are the risks?

Then the business office of Bredt Martin and company, as you start working on the work breakdown structure and the work packages that you're going to earn value against, you can now

integrate that set and say, okay, there's a certain percentage of the equipment and the design on board, that exists. What are those? Can you get them at fixed price? And then you get a cost. So you have a small amount of reserves that you carry on that.

Over here, you've got to make changes. So now, you're looking at saying, okay, I may have to hold a higher reserve for that and I can work this with you, Mr. Contractor, and say, okay, what do you think each of these might need and we'll put that in the reserve pot. I'll keep that at project-level. You may keep perhaps 5 percent of it, whatever, so that we don't have to go through some kind of a change order activity on the contract. But we'll negotiate that.
Over here is brand new and I've got to hold 100 percent reserve on that because I knew from my power systems switch thing experience that it was more than likely 100% reserve was going to be needed. Okay?

At the end of each of presentation, we had the element managers describe their estimated cost, what did they know and how much confidence did they have in that. Next, my business manager could take that and, with the schedule people, start working a schedule of events that you were going to "earn" against and then do the integration of the critical path to the work schedule against those numbers. This would expose the significant risks. You could kind of see where the tent poles were going to come.

So, it was clear to me that, as I describe in here, the way you develop an initial significant risk list (SRL), is to do a CRR, because then, with that sheet of paper, if you look over in the new and in the middle columns, and you can pick out where the risks are you put that down on a list. That's how I got my initial cut at the SRL, basically.

Now then, I could take the elements for each of these subsystems with its schedule, and my scheduling guys could integrate that. And then we could load the workforce [labor #'s and

rates] that would produce the earning of value against that. And we did that in two ways. We put together a schedule of events, and Ralph Barter, the older gentleman, analyzed the schedule. He counted the events on the schedules that Lockheed Martin put together on their integrated schedule with the critical path and negotiated which ones were key so we could see exactly how many events we planned and which/what did we actually complete.

And then, what we had to do was take the EV and the key came from my business manager, who knew something about engineering. Fortunately for me—and this is why I think that all business managers of all projects should have a technical undergraduate degree with a master's in business.

NIEBUR: Okay. That's kind of specific.

ATKINS: In my case, it was an electrical engineering undergrad degree and a master's in business administration where he looked at performance management stuff. So then, in taking earned value every two weeks or every week, he could do it quickly because he understood the language of engineering. He'd get right with the engineer and be able to avoid being "bloviated" with jargon. He could avoid "fluff" and vague promises. "Did you make the events or not?" Charts went into a virtual server. You could call it up over here [See LMA data quickly at JPL]. And nobody had done that before, either.

NIEBUR: Really?

ATKINS: No, we didn't have those kind of virtual meetings with electronic network access through the company security firewalls that could facilitate getting information across institutional boundaries, yet still protect proprietary things. That really had been a traditional barrier to different institutions working together quickly and efficiently.

NIEBUR: Yeah. By the time I got to Headquarters, everybody did that and everybody was learning earned value, but not well. [laughter]

ATKINS: Yeah, there was nothing—.

NIEBUR: Wow. You had created a lot of things.

ATKINS: When we started Stardust—nothing. And yet, we were up against it relative to how we were going to make it. The fact was that we started six months behind *Mars '98* when they kicked off on their spacecraft development. But we launched virtually at the same time. So, one of the questions that I was always afraid somebody was going to ask me, before I had really figured out the answer, was, "Okay, kid, how do you think that you're smart enough to start six months behind these people and launch at the same time? How are you going to do that?"

So, how did we do that? Well, it turned out—here's where McNamee [*Mars '98* PM] comes in—when we started looking at the subsystems that we were going to use, we wanted to inherit subsystem designs to the maximum possible, that we could pull off of *Mars '98* as they were going through their build and test at LMA ahead of us. So, we were going to have three spacecraft in a pseudo "assembly line." Ours was a much different configuration, but the

electronic boxes and software was going to be very similar, or even the same, and have the same people working on it. We got economies of scale there. There were some contracts that Lockheed Martin already had in place like the star camera and the radio. We could "piggyback" on these and add units to *Mars '98* contracts.

And so we had to go back to Headquarters because things were already moving along on *Mars '98*. John had a contract for a certain number of radios. What I wanted to do was to get John's contract modified where he could add a radio or two on there for me.

"Well, that's fine," John said. "Where's the money? And you need to get moving. They'll close the line after our deliveries." The schedule we had proposed up to that time and Lockheed Martin had put in their plans was that we didn't need to start contracting till [a later date] here because they were still sequential rather than—

NIEBUR: Right.

ATKINS: concurrently. Besides, we wanted to get all this rolling early, anyway. So, we needed to have part of our end- to-end information system in a test bed ASAP. So, if you could get the *Voyager* camera, which we were going to use, with new optics and some electronics, and you had some electronics, the radio, the flight computer, etc., you've got your Command and Data System, which could be a unit like you have on *Mars '98,* but you put the right kind of cards in for Stardust, you could get yourself to a test bed in the fishbone [concurrent engineering paradigm] pretty quickly.

But to get that going, though, we had to have the money. We had to go back to Mark [Saunders], hat in hand with Lockheed Martin and say we need to—I think the term is strange,

but it's the one we used. It's Lockheed's term – "prefer" money, it's "move forward", give me a preferral.

And so, we went back and got a preferral to add on to *M98's* contracts. We showed with the funding profile that if they shut the contract down, we wouldn't be able to stay inside our cap and that this made a lot of sense. Fortunately for us, in more ways than just one, *NEAR* was doing very well with its cost experience. And so, Mark had money available in the Discovery program.

NIEBUR: In that fiscal year, which they ended up not needing until later.

ATKINS: That's right,

NIEBUR: There's an efficiency of the program.

ATKINS: So, we were able to "piggy-back" and take advantage of all the 'chopping through the jungle' that John's team was doing on *Mars '98[Climate Orbiter,* and *Polar Lander]*. Stardust was drafting like a bicycle racer.

NIEBUR: Nice.

ATKINS: Not only that, but since they were rolling some people downstream from spacecraft to spacecraft as work was completed, in earned value I was getting senior, experienced, engineering guys to work on Stardust and do the reporting. And my business manager could then call up

each week, and because he had the technical culture if a guy said I'm going to be doing X, Y and Z and delivering that, he'd sometimes be able to say, "You're kidding me. I know something about electronics. What do you mean by that?" So, he could probe that and get it to where EV was really known.

And we were counting and using objective metrics [EV] on progress. For each element below the Project Office, we had cost accounts and their earned value chart was then printed out by the business office. That's how we knew, for example, that aerogel was in trouble early. That's how I knew that I had software issues—okay, software is always measured [and this always just drove me crazy].

NIEBUR: With lines of code.

ATKINS: With lines of code, exactly, lines of code. They'd say, "Oh, don't worry. Everything's fine. We completed 60 lines of code this week." So, they got this picture that always goes this way [asymptotic curve] and it goes asymptotic and it never gets there. Okay?

It was a stark comparison with our EVM system in that we were employing it. But *Mars '98* was not. That meant that I would get some EV data and John wouldn't have it. I called him up and said, at one particular point I remember, we're going to (we had to each report monthly on our progress in these monthly reports that we did with [Ken] Ledbetter [probably a Flight Program Review]). And so, I said, we're going to call software "red" because they're not where they should be. He said, "Well, we don't see that in the Mars program." [They had Norm Haynes at JPL as the Mars Program Manager above them at that time. The Mars program was over in a different area.]

John said, "We're not calling it red." The Mars program had been in so much trouble they were viscerally [maybe in denial] against actually doing it. But, I said, I've got to call it red from my EV data. And so, I did, even though they were not going to. And then, as soon as they got up to do their monthly review, Ledbetter says, "How come you're not red? Stardust is saying that this is—" So, the truth came out and more people had to be added and things had to be adjusted.

And I'm not saying, "Oh, I was just so brilliant." It was just because the data came out and showed that from the standpoint of where we were, we weren't getting where we should be in terms of what the function should be. And if you have a test bed that you're supposed to be using some of the software in early, you'll be able to say how come it's not. You're not getting the functionality in.

So, what I learned [and now always argue for] was that the software should be measured in terms of its functionality and what are the functions that should be completed. Then count the functions and what level of robustness the functions are.

NIEBUR: And just stack it in earned value chart.

ATKINS: Right. We wanted to stack it in earned value. But "lines of code" is too vague. So, we got very skeptical on EV items that were subjective in that way. I still don't see how "lines of code" can't signify two entirely different realities.

And we had the *Voyager* camera come in. And so, because we were able to get the camera early since much of it was inherited, it was easy then to get image data to drive completing an end-to-end test bed.

Finally, Vellinga and company were very good at negotiating with the subcontractors to get fixed price, firm fixed price, on about 85, 90 percent of the Stardust subcontracts, because see, they'd been buying from a pool they knew well, so competence and trust were high, so I benefited from that, as well.

An interesting side story had to do with the launch vehicle people. Darin Bedell was our launch vehicle provider lead from Goddard. They handle all the launch vehicle issues and interfaces for NASA HQ. He eventually had to move to Kennedy when they shifted that function.

We were having a review in Denver and LMA was presenting the challenges of the flight system mass. We were incorporating some configuration features of *Mars '98* because we thought our LV launch performance gave us plenty of mass reserve. But then, he came in that day and said that the launch vehicle curve that they had on the Delta 7326 (denotes 3 solid boosters) was too low by a factor of [I can't recall exactly] but a large amount of mass, kg. No way were we going to be able to launch because we were just too heavy for the new curve. This put LMA through a crash redesign activity of trying to make this thing lighter. They dug down and they couldn't get it down to where it was going to be able to be done on a three solid Delta. So, I found myself in the position of saying, we've got to change to a four solid launch vehicle.

And so, I went to my advisory group with the data that I had and said, "we have to quit right here if we can't get a fourth solid. The way I see it, that's the way out."

So, that meant we had to go hat-in-hand back to Mark. Well, Mark is, as you said, a tough customer and he doesn't suffer fools lightly. [I had already thought that I was played the fool by the selection process not having confidence in me. I was trying to prove him wrong the best I possibly could and thought I was making some progress.]

So, Vellinga, Brownlee, and I got on the phone with Mark and said we've got to talk about this launch vehicle issue, get this resolved, and it's not our fault. I want to be sure you understand that. We've been going by the launch vehicle curves that we were given and if those are proved, if the performance is okay, we'd be okay. But they're not.

[break in audio, for rescheduling purposes]

NIEBUR: We're talking with Ken Atkins. This is August the 10th, 2009, tape number three.

ATKINS: Okay. So, we had to go back hat in hand one more time and order up the fourth solid. That telephone call went amazingly because it was very—that was the call I did not want to make because I knew that there was a chance that they'd say, well, you've got to meet it or whatever. They put the bug on somebody, particularly if they didn't have any money.

And so, I called up and just laid it out and said, here's what happened, it's not our fault, we've done the best we can, blah, blah, blah. And he said how much do you need? And that's when I almost fell off the chair because when we talked about the fact that we'd already gotten a pretty good chunk of money in preferrals to get the contracts underway, we're talking about another unknown amount, but there was some amount of money to buy the fourth solid.

And so, he said, "It just turns out that you're in luck because of *NEAR* I still have some money and that makes it a lot easier for all of us, okay. So, I was able to get it.

But, he said, "I'm not going to pay for all of it. You guys need to pony up for half of this as part of your project cost." So, we said, "Okay, that's fine, we'll carry that cost and put it in."

So, that was the deal we made. We got the money. We put the fourth solid in there and we went forward.

NIEBUR: And did that end up being paid back in later years?

ATKINS: No. It turned out that that was forgiven because they didn't need the cash. We'd come in under the cost-cap at launch. They didn't have to go up to the limit of the obligation authority they agreed to in the MRDA. So, we got the fourth solid into the project and we then proceeded to work towards getting our units in, and getting through CDR. We did the Confirmation Review and that went fine back at Headquarters with Wes Huntress and we were off and running into [phase] C/D.

The problem that we did run into was that aerogel—when Peter and Don had originally talked about catching comet dust with it in the initial proposal—was a certain type and technology level. It wasn't really as clear as they turned out to want and it was of a uniform density. But then, in subsequent meetings the science team kept "creeping" the requirements finally wanting a variable-density material that was less dense on the impact surface, giving a "softer" initial impact, and then increasing through the "catch-tile" to a higher density to ensure stopping the particles inside the tile.

To get there, they first tried it with several layers of different densities, but they worried that the change at the layer interface might cause some damage to the passing particle. They ended up needing a gradual, continuous density change through the tile. This turned out to require a complex process to invent and apply.

All this was necessary to produce a qualification unit for LMA to test in vibration, etc. so we'd be sure the collector wouldn't fall apart during our launch climb-out. . The aerogel team was just having a load of trouble. And to make a long story short, Peter's team was not making the milestones that they planned and that were in the earned value system. They were behind schedule and beginning to get into the critical path. Not only were we not getting to the quality (clear, variable density), but he came up with a "Rube Goldberg" type arrangement to put the aerogel tiles into the collector tray. He'd promised a demonstration to show progress then delay it. When he finally couldn't delay our pressure any longer, he scheduled it. The PI, my systems engineer, and I went down to his lab expecting to see this thing work, and it wouldn't. I was really getting concerned.

We had to make a change. This was a "mess" and we had to recover. I decided that we had to have a different guy in charge of making sure that it happened. Fortunately, Peter had hired Dr. Steve Jones, who was a super chemist and specialist in aerogel technology. He was just being buried with the minutia and lack of leadership on the aerogel team. He was frustrated by the micromanagement the team was under. I made a decision to put Steve Jones in charge and moved Peter out of the way. Happily, Jones was able to not only make the aerogel, but he was able to install it with amazing simplicity. They installed it using the wooden tongue depressors you can get at any medical supply. "Rube Goldberg" was out.

Another "straw" that that drove us to change involved delivering the qual unit to Lockheed Martin. We shipped a unit to Denver and they put it through vibration testing (to simulate the launch environment) and it all just fell out; just [crumbled in pieces]. There was consternation with that. That could have ruined our chance at succeeding.

But, in the final innings Steve was able to save the day for the aerogel team. We did get through qual testing and moved on to being able to deliver a very good flight unit that, of course, worked extremely well in catching comet dust.

In the interest of not getting or staying too deep in the weeds, let's get to a few things that you might be interested in just knowing. (Atkins produces an IEEE Paper he authored in 2003) In this document, I wrote about capabilities versus requirements, how you get to a risk adjusted base line, how you earn value and manage against cost-to-go because as I pointed out earlier, you had to have measurable criteria for understanding how you are progressing. This is crucial to stay inside cost constraints of a program like Discovery. If you can't have a way to move the science requirements down in a de-scope, then you better have 100 percent or more reserve ($ & schedule) on everything. Otherwise, the project ends up driven out of the cost envelope by inflexibility in requirements.

A mission with a single scientific goal is really tough to work as a capability-driven mission, particularly on something you've never done before. You can't do that with a fixed cost. You've got to realize that you're going to have to invent things or change things. Even though people say, "I can do this easily", they almost always can't. And you might as well just realize that there are missions that have to be requirements-driven and some where you can get a lot of existing equipment and experience that you can do, IF you have flexibility to reduce some of the requirements, or just avoid letting them increase to a point of strangulation.

And Stardust's success was basically because it could "draft" very carefully behind Mars '98. We did have a good, innovative way of implementing earned value system with a crisp, streamlined business management process that could validate real earning was happening. This turned out so well that, there were times in the project where I had significant unencumbered

reserves as a percent of cost-to-go. When the reserves got up to certain levels, I could release them with little risk of having a problem later on.

I recall one specific instance where we got up to a good level of unencumbered reserves. We felt we perhaps could even reduce risks if we spent some of the reserve in what we called a "pre-emptive" strike on some lurking issues. The business manager and I decided to put out a call for bids on reserve to apply on ideas that could reduce risk. We sent a message over to Lockheed Martin saying, "We have some "extra" money, do you have any ideas about applying it on some pre-emptive risk reduction, etc.?" And, though they seemed excited about the prospect, we heard nothing. No proposals were forthcoming. We waited a while longer and got nothing, got nothing. Finally we decided to find out why no bids were coming in. We called our LMA program manager and said, "Well, Joe, we said we wanted to do some risk reduction. Why didn't you guys propose anything?" He said he'd check it out; he was surprised too. He came back later and said, "Our troops just didn't believe you. We've never had any project come and offer to give us advance money to cut risk." It was a foreign concept in the culture.

But we did manage to get that in there to where we were able to get a couple of things moving. I think in the final tally we spent about a $1M on risk-reduction items. But there was a "catch." It makes your contract a little bit complex because if they're doing something for risk reduction, then does it earn fee or doesn't it? Well, it might. So, we had items in here (lien/budget log) that we had to decide whether the particular activity was a risk reduction (RR) item or whether it was an overrun (OR) or whether it was a change in scope (CS). This caused us to be very careful in terms of things that came into the baseline activity with Grammier and his Project Engineering and Integration Team (PEIT) looking at the requirements, understanding

the earned values necessary and then looking at the contract and saying, okay, if this is a risk reduction item, let's negotiate about whether it earns fee or not.

The rules were 1) if it's an overrun you guys lose some fee because of the incentive share line. 2) If it's a change in scope, fine, I can understand a change in scope. And if I could handle it inside the project reserves, I would. 3) If it was totally outside our baseline, like the change in launch vehicle, then that's what the Governing Board's for because that would be a change in overall project scope. We'd have to modify the "4 Party Agreement." Which we did a couple of times.

And so, we were able to employ a budget change log (ref example in K's Paper) to consider, track and work our risks. There were hard liens, some were from project level, some were Lockheed Martin and some were soft liens where we would take something and say, "okay, this is a problem that we've got coming up. It may or may not happen. What do you think the percentage probability is on its actually occurring?" And we had some at various items that were low, which would be 30 percent. Later the probability might go up or down as we got more information. First, Lockheed Martin would come with a preliminary estimate—there was a term we used for it. We called it a "ROM", rough order-of-magnitude, estimate. It wasn't a hard estimate. It wasn't a formal proposed amount. So, it was like a "ballpark" value. We could multiply the probability % against it to get a "soft" lien against reserves. With a forward-looking reserves strategy like this we could map and update our CRR SRL as we progressed in time.

In other words, because of our capabilities versus requirements review set up and our integrated schedule, we knew where the tent poles might be—like the star camera or whatever the individual subsystem was going to have the risk and when it was likely to occur. We could then divide our reserves into 3 categories: soft liens (30 to 50% probability), hard liens (> 60%),

and unencumbered (available for future unknowns). If for some reason we didn't experience those things, then my reserve % on cost-to-go would grow. I could go into the monthly management meetings with HQ and say, "Okay, the current amount of unencumbered reserve translates into an ability to employ ("buy") this many full-time equivalents (workers) from here to launch.

When I got to where there weren't that many people available—I mean, you know, we had more people available than we had problems—then, you could say—.

NIEBUR: That's a nice place to be.

ATKINS: It's a nice place to be. Then Headquarters could sleep at night and so could I because we knew we had enough reserve to make it.

NIEBUR: It seems very methodical and well planned. I'm very impressed. I mean, creating this out of not much, I'm just a little stunned in general about how mere humans can put together these things and go off and collect pieces of comets. But seriously, putting together project management like this without having had previous experience, that's really cool.

ATKINS: Well, it came from having to be organized, both in the military and in running line organizations over many years. Well, one of the things that then I did that sort of wraps this all up is to write this paper to capture the process in a list of ten steps. You can take this along.

NIEBUR: Thank you. I will.

ATKINS: And read it, and then I can send it to you electronically if you want it. And I have this. This was a final report on analyzing the cost details for Stardust that I completed in 2007 because I hung around long enough in the interim employee program, and then I was part of the cleanup process on corrective actions after *Mars '98* failed.

NIEBUR: Oh, were you really?

ATKINS: Yeah. I was the leader of what we called the Project Leadership Process, PLP. After *Mars '98*, JPL had to prepare responses to the corrective action notices (CANs) that came from the Failure Review Board. Since I was the PLP owner, they said, you get those CANs pertaining to Project Management. That meant I had to put together CAN teams for each of these, report to the JPL Executive Committee (EC) every week on progress and results until they approved the analysis/finding and the recommendation on a response action. That "sign off" would close the CAN if the FRB agreed. So, I was around doing these things. I recall I had to address about 10 CANs. One of them resulted in a plan to train our project managers better. We really didn't have much of a specific PM training course in the early days, particularly for a faster, better, cheaper (FBC) program like Discovery.

Part of the "root cause" of *Mars '98*'s failure was a mentality that an FBC project could just get a few great people turned over to it by the line organizations, and they'd be able to handle all the project development processes at a great savings by not paying for any line organization oversight/supervision. And of course, that turned out not to be good because the Line just gave you a person, became simply a "body shop", and then walked away from you, if

you let them. This was to ostensibly "streamline" the project management and save money. Good for FBC missions—NOT. This approach really increased risk. And that was what "bit" *Mars '98*.

Since I had just come out of the Line when I was assigned Stardust, I had seen some of these risks were there on *Pathfinder* and *Mars '98*. I'd been against my Section just becoming a personnel provider without any accountability. Fortunately, for Stardust and me, I said, we are not going to do that. And Rick (Stardust Project Engineer) purposely got support from some VERY senior people in the Line organizations like our digital design guru, Don Johnson [the "spell digital" guy] and others like him representing other subsystems. Rick would then "sic" them on short term assignments with Lockheed Martin on issues and problems. And they would work sort of "by the time" and then come off the Stardust payroll. In other words, we put them in "Tiger Teams" as part of insight/oversight where they would work with Lockheed Martin in their green book meetings and system engineering to solve problems and check the correctness of the approach. This had really helped keep risks lower on Stardust. And it got Line management attention and accountability.

So, I'm still around during the Stardust flight phase, but no longer on the project. And I thought, "Well, there was a certain amount of money that we thought we knew as to what we paid for this. But, by the time we launched it and everybody went off to new jobs and everything else, the clean up was always left un-cleaned up. That meant there was no "final accounting" of the actual development costs for Stardust in a crisp, archival product available.

So, I started an activity I called the archival study of the Stardust cost. And I had Joe Vellinga from LMA on here for the flight system contract and [Walt] Boyd from my Stardust business management team. Bredt Martin, the lead planning and control person, was not

available. He had become a lawyer and some other things, but Walt Boyd had worked with him. Lee Rosenberg from the initial costing group was on, and me. And so, we went back. And in here, I noted that launch vehicle was handled "off project." That means it was provided by NASA and I didn't have to manage the cost of the launch vehicle inside my project. People have to do that now. They have to worry about the launch vehicle cost, I guess.

NIEBUR: Well, yes, but any changes outside the project's control are still handled by the program.

ATKINS: Okay. And so, my point is that there's a program difference for Stardust here. Our original proposal called for a Delta II with 3 solid boosters. That cost was a 'given' from HQ at $34M. However, in the actual development, it turned out that the HQ supplied performance curve for the 3-solid version was in error, and not in our favor. That meant we had to add an additional solid booster. This is an example of a scope change that was outside the project. Since the LV issue was definitely outside the "4 Party Agreement," HQ ended up paying for it and it was not a part of the Project Costs. In essence, Stardust was supplied with the 4-solid Delta II for the $34M. Also, we had off-project treatment of the DSN cost.

From a cash-flow perspective, we paid the PI and the investigators directly from HQ, bypassing JPL but this was part of the project budget.

Recall, Stardust was developed concurrently with the two Mars spacecraft. Testbeds, transponders, flight software, and star camera were virtually common. Much of every subsystem enjoyed commonality of design and parts. And in large measure the work force was common as well. That allowed uncommon—those are uncommon efficiencies in experience, in testing, in

purchasing parts, and, in large part, making it possible for Stardust to have been started 6 months behind *Mars '98*, yet able to launch only month afterwards. As another cost-saving 'kicker', the *Cassini* parts inventory was a boon that was unbelievable.

NIEBUR: Really?

ATKINS: Yeah, because Gavin had a lot of parts such as field programmable gate arrays [FPGAs] and things like that they did not have to use. Rick could get those for LMA at a favorable cost. In another case, we were then benefited in the MOS by that technique that I mentioned earlier where Com was able to negotiate with the Mars Surveyor operations project rather than the multi mission operations program that they had here and just add a node to something that already existed. And initially we got a fixed price for that. The costs for MOS could be shared between three spacecraft (two projects) getting economy of scale.

Finally, I was just going to show you a couple of other things just for your awareness that they do exist. One way that we worked to control cost—I have this electronically also—[unfolds large chart] was developed by our Planning and Control Team for the whole project. Right at the outset, they put together this total work breakdown structure for the project baseline in an Excel spreadsheet. This allows automatic recalculation of the project cost as things changed during development. It identifies work responsibilities and cost for each work unit for the involved organizations by color coding. For example, JPL's work is yellow. Lockheed's work is pink and University of Washington is blue. As we negotiated revisions in work elements, and updated costs assigning reserves, they could just plug in the new numbers and get an updated projected total cost. We could then quickly see if we were going to bust the cost cap and act

accordingly. This one is not my final, but we kept running/updating these over the life cycle to keep a crisp record comparing our base line and the projection so that we'd know exactly where we were coming out.

NIEBUR: Ken, how long were you project manager?

ATKINS: From May 1995 to July 2000.

NIEBUR: You retired in 2002. It was about that time?

ATKINS: Yeah. Well, a little before that. I had the Mars stuff to do before I retired. I mean, I was on an interim employ program. And then, I worked on under a contract, a tech service contract after that until a year ago this last April.

NIEBUR: Yeah, I saw that on the web. That's why I had the guts to call you. Didn't want to bother you in retirement, but I'm so glad I did.

ATKINS: No, it's fine, it's fine. One of the things of interest to me was capturing a credible record of the Stardust development phase. I wanted an accurate picture of the "before" and "after" costs. And now I have these four items. They're going into the Cost Analysis Data and Requirements (CADRe) document that I'm reviewing and updating with the cost people here at JPL. It shows a total value in that pink summary box for Phases B, C, and D of $164.6 million.

Of this number, $24.2 was designated as reserve. Phase E was planned at $37.2M with a 10 percent reserve of $3.7M.

NIEBUR: That's not all that much reserve.

ATKINS: No. Separating out the baseline Phase E, that $37.2M with their own 10 percent reserve in it, from the total BCDE, showed that the development PLAN (BCDE) was $103.2M plus the $24.2M equaled $127.4M. The reserve percentage for BCD was then $24.2M over that or 19.4 percent. The actual reserve required in BCD turned out to be $23.253M leaving $975K at launch, available to be reprogrammed into Phase E.

Now, Duxbury (Flight Phase PM) was complaining at that time that he kept getting BCD bills. He was in Phase E and saw it as having to pay them out of his $37.2M planned, but as I've shown there was almost $1M that was rolled into Phase E. That would have made his reserve $4.7M! Why was this reserve okay? It really was because nobody really knew in an FBC program like Discovery what was acceptable. In fact, if they came in proposing a reserve like this on missions after Stardust, when we'd experienced the *Mars '98* failures, they wouldn't have gotten approval.

NIEBUR: Right, useless.

ATKINS: Because they didn't have the kind of benefits I've noted for Stardust, they'd never let them go forward because a "rule of thumb" value was set after *Mars '98*. I think it was you had to have 30 percent or more as called for in the Design Principles developed in response to the

CANs. Recall, Stardust had *Mars '98* running just in front and we had also developed a strong scope control discipline.

NIEBUR: That's so important.

ATKINS: To avoid requirements creep. It was indeed important. In fact, as an example, a small group of the Science team decided they wanted to add an instrument to actively capture gas residue from the comet, "volatiles." They proposed this late in the program; it would be mounted on the mast that that put the collector up into the stream above the shield. The group put a lot of pressure on Brownlee and wanted him to force me to add it.

It had been in originally. But we had taken it out to gain cost and risk credibility at the selection. Now they wanted to sneak past me to get it back in. That was the one time that I said, okay, I'm saying no. Brownlee, the PI—and I talked to him—felt between a rock and a hard place. He didn't want to come over as a roadblock to his science colleagues, but he knew the real constraints on the project. I told him, "You just take it to the Governing Board. They'll back me up and I won't have to worry about this anymore. And so, that's exactly what he did. They put together their cost, etc., and Brownlee took it up to the Governing Board and said, "Ken said we can't afford this." Lockheed Martin said, "We back Ken." So Don was able to go to his Science Team and say, "Okay, I took it to the Governing Board and they said no, we're not going to do that." So, it was end of story.

And the same thing happened when people from Ames Research Center came in and wanted to add an active censor in the aeroshell heat shield so that during the atmospheric entry coming back to Earth they could assess the performance of the heat shield during the return.

And I said, "No, we're not going to do that." We had too much trouble just getting that the heat shield manufactured. It was a new technology and I wasn't going to risk anything like having a hole in it that might not be totally sealed by this Ames sensor. So, it was a similar kind of thing.

Anyway, compared to the baseline PLAN of $127.4M, Stardust BCD actually came in [at] $123M. This meant that $4.4M of development new obligation authority (NOA) had been carried over and was available in Phase E. It turned out that because we were so tightly managing on the cash-flow we'd received, we never had to request the full NOA available. We really just forgot about it because our reserves were adequate. That turned out to be a Discovery I made in this study. I was amazed. So the original NOA that was available, but unrequested, more than covered any residual development charges (e.g. late billing cycle on the contract) that flowed in. In fact, Tom (Duxbury) was getting a 'windfall' from the uncommon advantages we hadn't initially planned for in BCD, but we ended up benefitting greatly from. We were just so focused on the cash-flow, our Planning and Control Team never stopped to think NASA was only funding what we actually needed to spend and not up to the full NOA PLAN. NASA really got that windfall, and could dole some of it out to Stardust in Phase E after the Genesis mishap (its chute didn't deploy during atmospheric entry) to take care of the paranoia that something similar might be lurking in the Stardust design. Of course, our records had shown that the gravity-activated switches were fully tested in the Stardust configuration, while, unfortunately, Genesis assumed the design implementation was the same for them—but it wasn't.

So anyway, that's sort of the end of the story. It sort of put Stardust on charts in places that nobody had been and probably won't be again because it was a point in time where faster, better, cheaper meant something. I knew that if we got 10 percent out of our cost plan with Administrator Goldin, Discovery manager Mark Saunders, and company in that era a

cancellation review would have been called. And it wasn't till later that projects, like Dawn and *Deep Impact* walked in after that with things like—oh, who was it that got in trouble right away? Dawn?

NIEBUR: *Deep Impact* was first.

ATKINS: *Deep Impact*, yeah. *Deep Impact* came in and they proposed certain kinds of things. And it was just not in there. They didn't have anybody on there. I think Brian Muirhead was the first guy on that thing. And they just were going the same way they did with *Pathfinder* and there wasn't the discipline. They didn't have a Bredt Martin, the guy with the technical degree and an MBA as Business Mgr., and they didn't have a solid contractor like Lockheed Martin that had some experience in earned value management and could understand how to tailor that for the faster, better, cheaper approach.

One thing that was really crucial was the loop between the taking of the earned value and interfacing it quickly with the contract at Lockheed Martin. For example, if I'd given a go ahead on a change in scope task that wasn't in the contract, and they started working on it because they had the okay, the earned value system would show an overrun immediately.

So, we worked out a very speedy loop between our contract management and their contract management by letter that once the PEIT made the decision, the change order was passed immediately to the Planning and Control team who then took that approved change order and, since our contract support person was part of the P&C team, sent that letter right away to Lockheed Martin's contracts persons, Sally Wakefield and Rick Price. Rick put it into the earned value system, e.g. made sure the task was modified to contain the new work, and when

the work started it earned value against the new plan. It was simultaneously updated by my business guys, and then when it came out on the monthly, I could show that we were earning value against real, approved work.

NIEBUR: Right. Nicely done.

ATKINS: Yeah, okay.

NIEBUR: So, I have one major question left. I haven't had to ask you any questions. You've been so wonderful about walking me through the history and telling me the stories. I appreciate it. I was a little curious, as I am with all the missions, about the relationship between the PM and the PI. It seemed that you had a good relationship with Don [Brownlee] and that you were able to back each other up and to talk informally. What went into that?

ATKINS: It's a very good question and one that we struck right on as being a plus. Brownlee has an undergraduate electrical engineering degree. So, he was an engineer at one time before he became a scientist. So, he was kind of like Martin in the sense that he had degree A, and then he went on to become a science, degree B, guy to study space particles.

Don also had been part of the Halley Intercept Mission activity in the late ‘70s. He had captured a lot of space particles with balloons and high-flying aircraft like the NASA U2. And Don's demeanor was very—he was interested in the science, but he understood the engineering enough to say, okay, I'm delegating this to you, Ken, and the trust that we'd built up over the years, etc., was enough that we could operate together when tough issues came up.

As example was when I tried to get the deputy PI moved off, because he was the guy who was responsible for the aerogel development and had failed. I tried to get that; we had some meetings where we discussed it. But removing a deputy PI is not an easy thing to do at Headquarters or any place else. And so, that was a little beyond the scope of the PM, and we tried to just work around it instead of biting that bullet.

NIEBUR: Were you successful in removing him? I don't recall that part.

ATKINS: No. And he did some things in the recovery, I think, that were okay. He wrote up some stuff and he was in there and he was aggressive and did a lot of work with the science people. But, if it hadn't of been for Steve Jones, the guy who really produced the aerogel, we would have perhaps risked missing launch it because he was that far off. And he would claim things that weren't true in the progress.

And so, I worked with Don and HQ and our management at JPL to restrict his travel. And so, we had to be able to be sure that he wasn't able to go places that he might decide to go on his own and lobby the science guys at other places to cause problems, like the "active volatiles" thing mentioned earlier.

Anyway, the PI relationship was very good, and certainly, it facilitated things because I could help him in dealing with issues that might arise about my management. On some projects the PI PM relationship would just be killed with it because a pressure group in science might say, "Well, look, you have the authority to demand this from the project and we are all on the science team." So, it becomes an "us versus them" between the project and the science people, who are the "passengers" on the mission.

And that's the way JPL had always done it. The usual situation was to have science working groups outside with PIs over there, and the project manager over here trying to support JPL's performance on the whole flight system. HQ or JPL management then, many times found themselves in the middle. But on Discovery, they made this crucial, and I think important, change if the PIs are the right kind of people. They said to the PI, "You're responsible. The PM works for you."

So, from the standpoint of a scientist who's really interested in doing science: if he has an institution that has done lots and lots of hardware and picks the right industrial partner and understands how to prioritize the requirements, he can let a good project manager help him get through it. And that's what Don did. I don't know what he says about it. You can ask him. But, from my perspective, it was a powerful team.

He's so funny because when he was at the Cape and we were going through the last days of launch and we'd miss him on something. We'd chase him down on the cell phone and say, "You need to come over to the MOSB (Mission Operations Support Building)." After he got down there, well, he would have been off looking at manatees. And he'd be so excited about it he'd have to tell about them.

NIEBUR: Really?

ATKINS: Yeah.

NIEBUR: Don cracks me up. That's relaxed.

ATKINS: His attitude, after delegating the PM function, was, "This is not my job. This is not my area." Sometimes I had to cajole him to get his attention on the management aspects, "Come on, Don, come over here and sit in this meeting. You really need to know this." And then, Amiee, the Outreach Coordinator, she had a special role with Don regarding our Educator Fellowship activity. Aimee was, of course, in charge of that.

NIEBUR: Amiee Whalen [now Meyer], yeah.

ATKINS: Aimee tells the story that down at the launch, Don didn't want to be in the mission director center sitting there by the buttons with me. He didn't want to be in there.

NIEBUR: Really?

ATKINS: No. You know where he was?

NIEBUR: Un-huh.

ATKINS: He was out with Aimee and some of the Educator Fellowship people at the NASA camera site right on the road [I think they call it "Thunder Road"] that went down as close as you could get to pad 17A. He was out there on that hill, going to watch the launch from there. Well, when the count got down to the last 10 seconds, Aimee said he turned his head away [like a scared little kid] and wasn't going to look. And she said, "Stop that, you look, you have watch this." Sometimes she had to use her "Mother instincts."

And then, there was a touching situation for me. After we launched successfully, I had to go over to participate in the post-launch press conference. So, I go and I get in my car and I'm driving to the press conference and I know Brownlee's making his way over there separately because we haven't seen him. He's been out at Thunder Road and I didn't even know that's where he was.

So, I'm driving over there and I turn on the radio. Some background here. I remember that on the first day that we did the down-select briefing in 1995, LMA had set up the conference room with all the stuff that they were going to show the Selection Board to impress them with their readiness to succeed on Stardust if it were selected as Discovery 4. And as people were coming in, getting their coffee, and preparing for the review, they had Nat King Cole's recording of the song Stardust playing in the background. It was just soothing and sort of instilled calm in the whole process as we started everything that stressful day. In fact, we were so enthralled with the name of the project being this famous love song, for a while we tried to get the LV folks at KSC to consider playing Stardust over the loudspeakers while the spacecraft was going up. They wouldn't buy it though.

NIEBUR: Wow. A little distracting, but still very cool.

ATKINS: Kind of neat. So, I'm driving in my car and I'm about to go across the causeway over to Kennedy [Space Center] where they had the press conference. My cell phone rings with a call from Charles Elachi (JPL Director) to congratulate me. Then amazingly, right after this call, Nat King Cole comes on singing Stardust. I felt 'goose bumps' on that and the eyes teared-up while my emotions dropped a ton of stress. It was a great kind of "spooky." Nat singing at the very

start on that day in 1995 and then showing up on my car radio right after Stardust blasted off this planet. What a bookend!

So, I meet Don at the Press Conference and we go through this thing: congratulations, "huzzahs" and some brief press interviews. A side note here: We had scrubbed on the first day of our launch window. I don't know if you remember that.

NIEBUR: I have the records of that, yeah.

ATKINS: You know the reason we scrubbed?

NIEBUR: Un-huh.

ATKINS: We down to the last 10 seconds and we heard "hold, hold, hold" called on the radio net. There were lots of disappointed people there on that day. Some guests, who'd come from all over the country, had to leave, didn't get to see the launch. We scrubbed and we went through the whole reset process. And we went over to the Scrub Analysis meeting and found out the reason came up because we were doing this on Saturday, a weekend day.

On the vehicle, there's a transponder on the LV that's pinged [electronically queried] by ground transponders to determine its position and velocity in flight, like airliners. They start this process just before ignition and lift off. For Stardust, the box was to be pinged from three or four Air Force sites so that if the vehicle begins to veer off, those stations will tell you and you can trigger the destruct process to destroy it and preclude a crash on land. So, they have a watch on

that and it was a level that when those transponders ping the vehicle, the vehicle reads back and it takes time.

So, what happened was that generally and usually, they had three Air Force transponders that ping it about the same time and the current drops. The electrical current level is monitored to ensure it's above a certain value, rather arbitrarily set, I think. And that day, they'd added a fourth AF transponder because the Air Force had spare and I think some additional AF guys wanted to be there for the launch and whatever. So, they pinged it with four. So, at that time, when they started pinging the vehicle just before you launched, it dropped the current below the required level and it was mandatory to call hold.

NIEBUR: Because there was more yeah.

ATKINS: Well, the current being—

NIEBUR: Sure.

ATKINS: So, we got over to the press conference on the day we scrubbed and Ray Lugo, who was the KSC launch manager, had to explain what happened to the press. After he gave the whole description of what happened, one of these reporters says, "I'm (Name) from Dallas Morning News or Space News." I think that's who it was. The reporter says, "Let me see if I understand this right. What you guys are saying after all is said and done, is that you held a good rocket on the ground today. And Lugo says, "You could say it that way; we could play

semantics." There was laughter. And so, the next day, they had moved the line to account for 4 transponders drawing current. We once more counted down and Stardust roared off the planet.

Anyway, after the successful launch, we go through the press conference and everybody's real happy. It was a huge relief and thrill and excitement of that is something I'll never forget. Of course, we're going to have a celebration party that night over at the Navy's Trident Submarine Center, which is down there, their NCO Club. Amiee had arranged the celebration as an informal Bar B Q.

My mind was flying as I get in my car. It's a quiet and nostalgic time, knowing your life routine and objective of the last four years has culminated successfully. Conflicts—feeling highly excited with a great sense of fulfillment, yet loss and nostalgia over the closing chapter of the Development Phase. The everyday faces would be gone. The endless meetings, reporting and high-level attention were over. Next was pack for the trip back home. We were facing Phase E and a long voyage. It's a time for thought and it's quite a ways over to the party; back across the causeway, past the Mission Director's Center, then the stretch out past pad 17A down to the south KSC gate by the port; that's where you turn off to go to the NCO Club.

So, I'm driving back across that causeway and my cell phone goes off. I pick up the cell phone, and it's Don. "Where are you?" he asked. I said, "Well, I'm on my way over to the party. I'm just crossing the causeway." "But," I said, "I'm going to turn off [at] pad 17A and I'm driving out there to look at that place just to be sure that it's gone and be glad." He says, "I'm going to join you. I'm right behind you." So, he and I turned off and we went out there to the site, got out of our cars, walked up to the guard gate and we have some [promotional] pins in our hands and these guys are—they're very protective of that whole area out there. So, we walk up and we tell them who we are and they say, "Great launch today," and congratulate us. We

passed out the pins. They opened the gate for us cautioning not to get out there where there might be gases left or anything. We just stood quietly for a few minutes with our thoughts.

This was a little nostalgic "sayonara" and "bon voyage" reflection on Stardust. We were, in a way I think, affirming our bond as colleagues and friends. Then we went to the party. So, that was a special PI/PM interaction. It was very good. I don't know how he was with Tom during all the flight years, but every time I talked to him, he was having a good time. So, with that, I guess I can end here and say it was all successful.

NIEBUR: It certainly was. It was an amazing mission.

ATKINS: And now it's in the Smithsonian.

NIEBUR: Nice.

ATKINS: I'll tell you one more story that, amazingly, I just heard at lunch today. You remember the landing. Have you seen any pictures of he wore that night?

NIEBUR: I don't remember.

ATKINS: He had on a blue navy flight suit with all kinds of patches on it.

NIEBUR: I don't remember that.

ATKINS: Stenciled on the back of it was "Incident Commander." As I heard story apparently there was a lot of bureaucracy that had emerged at the Utah Dugway center in the wake of the crash landing of *Genesis.* To handle any repeat by Stardust and they decided they needed to designate a "stuckee", somebody to be in charge of how the mess was handled if we crashed again. Some process he wasn't too pleased about designated him. It was focused on responsibility for the crash site when the helicopters got out there.

So, Tom, as I understand it, took a satirical approach to this unwanted [and unlikely] "job." Since he'd have to go on one of the helicopters, he goes out and buys this blue flight suit. He put every kind of patch and pin on it to make it look a bit ridiculous. So, he wears that suit the night Stardust came home. And so, Tom in his "homemade" flight suit stands out on TV in the press conference [satirizing an Astronaut] and all that kind of stuff. His private "finger in your eye" joke. But the press and the team in Utah all just kind of picked up the quirk and they were having fun with it. I'm not sure how it happened but one of the guys that was out there with the safety group told me today that he'd recently been to Washington and over to the Smithsonian where the sample return capsule (SRC) is displayed and apparently Tom's suit's is somewhere near it. Personally, I haven't seen that in pictures of the display I've seen. But, if so, that's a "hoot"!

NIEBUR: Are you kidding?

ATKINS: No. He said it's right next to the capsule.

NIEBUR: I'm going to see it next week.

ATKINS: So, you tell me if it's in there.

NIEBUR: I will. That's so funny.

ATKINS: He says that suit is in there. Then, he says it's so funny because he got that thing to put it in their face out in Utah about somebody being called "in charge." If he was going to be in charge of that helo operation too, he wanted to wear that flight suit.

NIEBUR: That's funny. That's funny. Well, Ken, thank you for all your time.

ATKINS: Okay.

NIEBUR: I've really enjoyed listening and hearing from you and I appreciate this.

ATKINS: No. No. My pleasure.

[End of transcript. Note. This transcript was significantly edited and expanded by Ken Atkins.]