

COMMERCIALIZING OUTER SPACE: THE SATWG STORIES

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Today, space exploration and commerce, together with the requirement of sustainable life support systems for Spaceship Earth, have the opportunity to become the greatest cultural project in human history by evolving us into a spacefaring global community living compassionately within planetary limits.

--Ken Cox, *A Shared Vision for Space*, NASA/SATWG papers, 1993

Vision without hardware is delusion.

--Lockheed engineer

It was early October, 1993. Betty Sue Flowers and I were two of only four women speakers at a Robert Bly-style men's conference near Austin, Texas. I had just given a workshop on gender and evolution, and was attending Betty Sue's workshop on "The Hero's Journey: Telling Your Personal Story." At its end, I was approached by a trim, kind-looking middle-aged man whose silver hair, short silver beard, twinkling blue eyes, and ruddy cheeks smacked of Santa Claus--an image rapidly dispelled by his heavy Texas accent. Introducing himself as Ken Cox, an aerospace engineer who worked for NASA at the Johnson Space Center, he told me that he had enjoyed my workshop and appreciated my anthropological take on human evolution; he was organizing a little conference in D.C. at the end of the month and thought I might be interested. He spoke eloquently about the need for a more compassionate human future, ultimately touching on his efforts to develop a "shared vision" for the next step toward creating that compassionate future at NASA and in the aerospace community through his creation and nurturance of SATWG (Strategic Avionics Technology Working Group), a NASA/industry interface group that met twice a year. He showed me a copy of the latest vision statement he had developed for SATWG; it was called "A Shared Vision for the Commercialization of Outer Space."

I was hooked. What was an aerospace engineer doing at a mythopoetic men's conference? And what on or off of earth could be visionary about commercializing outer space? My mind filled with images of spaceports with giant neon

beacons touting Burger King and McDonalds. Was this what he was talking about? But his appearance belied that conjecture. He radiated excitement, enthusiasm, and good will, and he had that visionary look about him, the look of someone who always keeps the bigger picture in mind. Besides which, he was such a nice guy. I started to hope that maybe our space program had more going for it than I had thought. At least he wasn't talking about Star Wars. So I accepted his invitation, and attended my first SATWG (pronounced "satwig") conference in Washington D.C. later that month. Over the next two years I would attend three more SATWG meetings, in Phoenix, in Cambridge, and again in D.C. During these meetings I listened, both fascinated and repelled, to a number of countervailing stories whose individual themes I began, over time, to be able to sort out. Perhaps because these stories all deal with the potential for human expansion off the planet that is our source, it is easy to read them as myths.

Industry's myth speaks of the Government as Creator, attributing to it near-divine responsibility for generating cheap and easy access to space. The techies and engineers, lesser angels and acolytes in the heavenly hierarchy of aerospace, chorus that it's not design or technology that's lacking, but governmental money and mandate. The independent entrepreneurs tell their story of streamlining and efficiency, of willingness to jump in and fill market niches that increased government funding would open up. But government's myth says that the gods have fallen--they don't run Olympus any more; the polls do. And popular opinion does not mandate massive government funding of "space." As a government-funded agency, NASA's story as told at SATWG meetings is the story of a vast bureaucracy determined to hold onto its jobs and its identity. But the engineers and managers from NASA's five major centers (Johnson, Kennedy, Marshall, Lewis, and Ames) who come to SATWG tell many different stories about what NASA is and should become.

As conference coordinator and chief visionary, Ken was perhaps the only one present at these conferences who consciously thought of himself as a storyteller. Through him--and echoed by others--resonated the story of the New Age, narrating new paradigms and singing the praises of partnering, sharing, and collaboration. The contrapuntal story was one of the fierce competition that characterizes the aerospace industry--competition between divisions of NASA, between companies, and between countries. This competitive industry ethos is a source of tension at SATWG meetings, where industry managers and engineers meet, in a friendly and collaborative atmosphere, with their primary competitors in a world based on the myth of dog-eat-dog. All of these stories will be told in the following pages, along with my own story--the story of an anthropologist who knows something about myth, but nothing about aerospace, trying to hear each of the SATWG

stories clearly enough to sort out their interwoven threads. Ultimately these stories matter for the same reason that they are mythic--they all have to do with the shaping of the human future.

It is common across cultures for the action in myths, especially creation myths, to revolve around dualism and dichotomy. And indeed, these various SATWG stories do so revolve. The most dynamic of the SATWG dichotomies are a capitalist's nightmare but a storyteller's delight: industry vs. government, long- vs. short-term thinking, competition vs. cooperation, the U.S. vs. the world, old paradigms vs. new. Often in myth and story, it is the hero's role to mediate such oppositions so that the culture in question can live with them. Over time, the thematic appropriateness of meeting Ken at a workshop on "The Hero's Journey" became apparent, for I began to see him as the hero in this journey, the journey of the unfolding of government-industry collaboration in the commercialization of outer space.

GOVERNMENT AND INDUSTRY: THE SATWG STORIES

SATWG'S official literature informs me that it is "a NASA-sponsored avionics technical forum chartered by NASA headquarters in early 1990." The official purpose of SATWG's existence is "to facilitate an open dialogue between Government and Industry concerning avionics technology issues and potential resolutions" (SATWG correspondence 1993). The participants in the SATWG forums include "avionics experts from NASA headquarters and field centers, aerospace integrating prime contractors, leading avionics systems suppliers, small businesses that support NASA programs, professional societies, and selected universities." SATWG holds meetings twice a year, usually hosted by major aerospace corporations at hotels near their corporate headquarters. The hosts, which have included Boeing, Harris, Honeywell, General Dynamics, Johnson Space Center, Martin Marietta, McDonnell Douglas, Lockheed, Rockwell, Motorola, MIT/Draper Labs, and Marshall Space Center, offer SATWG participants guided tours of their plants, offices, and labs, as well as demonstrations of new products and technologies. As one long-time SATWG participant put it, "Everybody here comes basically to see what's going on, how people can relate to the space industry." Ken Cox, SATWG's founder and prime mover, explains it this way:

In November of '89 NASA administrator Admiral Truly asked us to go take a look at NASA technology and how the technologists, engineers, developers, and program managers can all work together better. So I was asked to set up a conference and we got everybody dialoguing...We started out with the idea of NASA talking to NASA for about the first four years. And then about 2 years into it, 2 years ago, the industry people who began to join in this dialogue

came to me and said "We would like to form an industry committee to go off and give you some shared ideas, but we don't want the government involved at all in the dialogue." And they did that--they called it the SIIG (SATWG Industry Interface Group), and ever since we've been getting their true feelings and furthermore we've been getting a consensus from industry about what we ought to be working on.... In some ways we're talking about cultural changes between the way the government and industry work together. We're kind of searching for common ground.

SATWG has thus functioned as a bridge between government-owned NASA and privately owned industry, between NASA's overly hierarchical, bureaucratic, and closed system and the new paradigm thinking that is beginning to permeate the aerospace private sector, between the cumbersome, slow and inefficient old way and the sleek, efficient, small high-tech firms that dart up and down like hawks trying to show the bureaucratic elephant which path might get him there faster:

Mel Saiz: I'm involved with SATWG--my dollars and cents bottom line is that basically I'm interested in getting more business for my company, OK? and in order to make that happen, I obviously have to go find opportunities. The problem is that the opportunities are fairly dry right now--we go through spells. This kind of organization--you get to exchange not only ideas in terms of technology, but also it is a policy kind of organization that's trying to re-orient the business, not only on the industry side, but mostly on the government side.

This government-industry tension/collaboration permeates SATWG and defines its ethos. Asked by an interviewer for NASA TV, "How receptive has NASA been to what they've gotten back from industry--to these suggestions over the past few years?" Ken answered:

Oh, I think it's been very profitable. The problem is that there is a small set of us that get what we consider excellent dialogue, excellent information from industry and then how do we turn around and get it into the bureaucracy and effectively implement some of the ideas? That's the tougher part.

The four SATWG meetings I attended lasted for four days each. I went to the technical workshops on Monday, as well as the general sessions that take place Tuesday through Thursday. Each time, I was one of the few social scientists present, and one of the few women, as aerospace is a heavily male-dominated industry. The Phoenix meeting, hosted by Motorola, focused on space telecommunications; the Boston meeting, sponsored by MIT and Draper Labs, addressed aerospace education. I draw most of the material in this chapter from the two Washington meetings, as their broader themes

("A Team USA Approach to Global Space Commerce" for the first meeting and, "Changing U.S. Space Enterprise: A Call to Action" for the second) and their emphasis on space policy best lend themselves to anthropological and journalistic interpretation.

The juxtaposition of "vision" with "commercialization" in Ken's vision statement which first took me aback turns out to quite accurately express a mythemic set of tensions and paradoxes in SATWG/SIIG's collaborative work between the simple capitalist desire to make a buck, and the unavoidable sense that efforts to fulfill this desire in outer space intrinsically carry a transcendent meaning and purpose--the next evolutionary jump for the human species. The issue here is what beliefs and values these engineers are ritually enacting as they co-construct the myth of American expansion into outer space, a new version of Manifest Destiny. One finds in their discourse a fascinating blend of vision and praxis, as is evident in Ken's focus on the concept of dual use technology:

DAVIS-FLOYD: Could you explain dual use technology?

COX: The cold war is over, and we cannot continue to spend the money for defense, for another war. On the other hand, there are some legitimate questions: "OK, if you move money away from the defense part, can you somehow use that money so that if there is another war, we can mobilize quicker?" So it's kind of like World War II where GM built cars--but could you convert them to tanks in a reasonable manner because you had thought through the possibility? So dual use technology--Clinton has said, we're going to put more money into civil space than into military space. However, if we're going to do that, can we use the technology money, and the manufacturing capabilities, and the infrastructure like launch systems or whatever, such that if we have another war, there is some way to use what we've done in the civil area to react better? That is an excellent question, in my opinion, because we can't afford to permanently fund the military, as if we are going to have a war.

DAVIS-FLOYD: It would be much better to fund NASA--

COX: Right. Now, NASA has looked at dual use technology from a different perspective. In effect, they have said, "Gosh, if you're gonna spend money in defense, or with NASA for technology, let's make sure that we can apply it to the private sector"--that's called *spinoff*. And that's fine. But that's the *minor* part of the problem. The major part of the problem is to develop technology on the civil side while keeping in mind the need to mobilize quickly in the event of another war.

Dual use technology is one of three primary domains that encompass the interests of the SATWG participants. Long range space exploration is another, albeit far less primary. The third, space commerce, was the most salient in the four SATWG meetings I attended. Ken provided some background:

This year, General Abrahamson, who actually headed up the NASA shuttle program at one time, made a speech at the AIAA [American Institute of Aeronautics and Astronautics] conference in January saying "it's time we got into space commerce--how is this country going to compete globally?" And in general, there hasn't been that much of a focus. So the purpose of this workshop basically is to start people talking about this and to see if we can set up some framework, so that when we walk out the door after three days, we can have some ongoing activity. In some cases it might lead to vision statements, and in other cases it might lead to a change in government policy in some areas, but it's very very important to talk about the roles of government, industry, and academia if this country is going to be both competitive and cooperative in global space commerce.

Ken opened the first D.C. conference with a presentation about his "Shared Vision" and the "Team U.S.A. Concept for Global Space Commerce" which stems from that vision. He began with a contextualizing retrospective view of the Apollo vision that got us to the moon. He reminded his audience that the Apollo vision called on the aerospace community to establish a sense of American pre-eminence in defense, science, and technology in response to the Russian Sputnik, and to become the first humans to land on another planetary body. He presented a "systems evolution overview," zooming in on the evolutionary significance of "central projects" such as the Egyptian pyramids, the great cathedrals of Europe, and the Apollo project, all of which served to "attract the best and most adventurous minds of the era, educate and stimulate human consciousness, and focus the energies of a population during an evolutionary transition to a higher level of culture." Here we see the mythic theme of the evolutionary straight line that carries us ever higher, from pyramids to cathedrals to the moon. In this evolutionary myth, higher levels of culture equate with higher levels of distance from the planetary surface. The logical corollary is that the "highest" culture of all is the one that will give us ultimate transcendence of planetary bounds.

This evolutionary perspective constitutes the foundation of the SAWTG worldview. Correspondingly, Ken traces a logical evolutionary route from land-and-sea-based exploration, to airfaring capability, to space-based exploration. The parallel argument that I will hear many times during these four days has to do with the creation of the infrastructure necessary for space exploration. Historically in the U.S. we traveled by boat, then train, then car, then plane. The infrastructures needed to

facilitate this movement included the dredging of shipping channels, the building of an intercontinental series of tracks and, later, highways, and the construction of airports, the identification of airways, and the maintenance of a vast network of air traffic controllers, government regulators, etc. Because of the low initial payoff and high up-front risk, none of these could have been made to happen by industry alone. The government had to make the initial investments in creating the infrastructure; then industry could take over. And so it should be with space, they say: the government must help build the necessary infrastructure:

COX: If this country is going to compete in space in the commercial arena, *we must have an affordable way to get up and down*. And so the whole question of launch operations --how we get the cost down--is an essential breakthrough that has to occur before this country is ever going to be really involved in space commerce in a global sense... We're looking for things like, hey how 'bout tourism in space, new things, that say--Brown and Root or one of the construction companies should get together with Exxon on the industrial side and go do something without ever really talking to the government. So what we're really talking about is that government kind of has to provide the basic infrastructure to get up to space, and get down, but industry is where the action really is in the long run, with market-driven ideas, entrepreneurs, and so forth, so one of the biggest things we've got to do is figure out how to get up and down in space much cheaper than we do now.

Interviewer for NASA TV: So do you think collaboration between government and industry is our best bet for future space programs?

COX: Absolutely. Now, part of it is collaboration between the Defense Department and NASA and the other elements of the civil space program--the Department of Transportation and the Department of Commerce are involved--so we're really talking about, in some ways, the potential for better integration, better collaboration, within government, as well as just a thorough understanding of how did the railroads get started, how did the airplanes after the Wright brothers get started--all of that didn't unfold immediately. There is a role for government at the front side, in the infrastructure, but the worst thing you can have is for the government to stay around for too long, get involved in the operations, and then you get involved in the bureaucratic process.

Here Ken speaks industry's myth of the Government as Creator: if God will only set the universe up right, humans can handle the rest. With sufficient--and sufficiently cheap--launch capacity in place, industry can move in and further human expansion into outer space while making a profit. This contradicted what I quickly discovered was my extremely naive--albeit quite common--assumption that the reason we're not out there trekking through the stars just yet has primarily to do with a lack of appropriate technology--spaceships, replicators, warp drive...Not so, according to the engineers of SATWG. Their story is one of protest that the transcendent potential of space technology goes unfulfilled. They insist that it's not the technology that's lacking, but the national will, the commitment, the money. Building a space infrastructure is a long-term commitment which the U.S. has not been able to make. The story here revolves around the long-term/short-term tension that permeates aerospace futures planning and government-industry relations. It is precisely this sort of tension that Ken intends SATWG and SIIG to mediate through their conferences:

COX: In Florida about eight months ago we had a meeting where we heard presentations on the long-term plans of the other countries that are involved in outer space. Boeing gave a presentation on the Japanese--what are they doing in aerospace, what are their plans for the next 25 years. Rockwell gave a presentation on China, we had two presentations on Russia, we had presentations on ESA [European Space Agency], which includes Germany, Italy, and Britain, and France, and so forth, and when we finished all of this, we saw *all of these plans for the next 25 years*, and we asked ourselves, what is the United States planning?

Well, we compete with *each other* before we get involved in the global arena, and our concern was that [we have no analogous plan]. It's our feeling that you can lay it out in a 25-year plan, you can have specific goals. Even if you don't meet a goal, it's worth laying out and striving for it. And that's what we really need....We're involved in the long view, as opposed to "I've got three months to solve this problem. Let's react to whatever the fire drill of the day is." [At our meetings, there is emphasis on] some very fundamental properties that I think would be good for the entire country. We could play a leadership role in terms of some pilot projects, because we are committed to thinking long-term.

COMMERCIALIZING OUTER SPACE: THE SATELLITE MARKET

During all the discussions about building the "necessary infrastructure" for access to outer space, I found myself at first hampered by my preconceived idea of what an infrastructure looks like. I could visually relate to railways and trains,

highways and cars, waterways and boats, and even airways--although they are invisible, I can sense their existence as my plane circles a city waiting to land without crashing into all the other planes waiting their turn. But spaceways? The resolution of my naiveté came with the understanding that access to space is about vehicles that will take you there--you or your payload, that is. The infrastructure that has to be built is one of launchpads, rockets, communication and tracking stations, and their supporting paraphernalia.

The current utilization of space is predominantly government-sponsored research with civil and military applications. Commercial space activities at present are driven by the communications satellite market, with other markets emerging but small in comparison (they include, for example, growing and manufacturing in zero gravity, developments in nano- and bio-technology, and power generation and distribution). Thus, the immediate use for such an infrastructure is the launching not of people but of satellites--presently the premier arena in which the "commercialization of outer space" is proceeding at an extremely rapid pace. You may not realize it--I certainly didn't--but every time you make an overseas phone call or tap into an ATM machine for cash, you are relying on one or more of the communications satellites orbiting the earth. One of the major areas of concern for the NASA and aerospace industry participants in SATWG is this enormously lucrative satellite market--a commercial venture which can be seen as a first step toward the stars, but which itself remains closer to earth, exploiting the market niche of LEO--low earth orbit. Over the next ten years, the total satellite market could reach \$120 billion dollars.

On Day One of the D.C. meeting, a presentation by Ken Cureton of Rockwell on "International Space Competitiveness Issues" identified four primary areas in today's international commercial space market: communications satellites and services, weather satellites, earth observation satellites, and the vehicles needed to launch them. For example, although at the moment space communications only account for 5%/year of the total worldwide communications industry (\$40 billion/year in 1993), Cureton pointed out that space communications are expected to continue as the largest potential growth space market, constituting a tremendous opportunity for commercial competition.

The key to increased competitiveness in the satellite communications market is increased launch vehicle capacity. Moans and groans were heard when Cureton noted that in the 1970s the U.S. had held 100% of the commercial launch vehicle market, a percentage which dropped to 51% in the 1980s as the French gained a corner on the market through their Ariane program; and to 34% in the 1990s, as ESA's market share climbed to 52% percent in 1993, and China's new program took 8%, with 6% split between the Russians and the Japanese. Concurrently, the U. S. began to lose its edge in the

commercial satellite market as well (87% in the 1970s, 71% in the 1980s, 63% in the 1990s). Cureton pointed out that the market forces at work here included aggressive commercial marketing efforts by ESA and the Chinese of their proven launch systems; political and economic pressures that forced Russia to begin to compete in the commercial space market; and the entry of the Japanese into the launch game. To regain what he and everyone present seemed to define as lost American competitiveness in the commercial space market, Cureton called for a "common, effective national vision for the future," a "clearly defined and consistent space policy," an effective implementation plan, plenty of capital investment, and the relaxing of governmental statutory constraints. All of these constitute a major part of SATWG's agenda--SATWG as a group is dedicated in part to helping the U.S. aerospace industry reclaim as much as possible of that lost market share. The more launch vehicles we can produce, they told me, the more satellites we can put into LEO, and the more money we can make.

Cureton's presentation was part of the "Executive Panel Session" held on the first day of the D.C. meeting. We are in a conference room filled with a large round table in the middle and chairs out to the walls. In the inner circle sit a Senior Policy Analyst from SAIC (Science Applications International Corporation), the Director of Space and Missiles from the AIAA, the Chairman of the Board of Eagle Aerospace, the Presidents of Lockheed's Technology Services Group and GDSS's Commercial Launch Services, Vice-Presidents from Loral, Rockwell, Boeing, Harris. These men control budgets that run into the hundreds of millions. From academia there is a Professor Emeritus from MIT/Draper Labs, and there are two women-- Madeline Pedego, CEO of EER-Lynx (a small private aerospace firm), and Lori Garver, Executive Director of the National Space Society. All are there to address the issue of global space competitiveness, and they are listening to a presentation by Tom Nicodemus about Japanese plans for the commercialization of space. All day I have heard lamentations about the lack of a specific vision for the American space program. At least five people have said the same identical thing: "Kennedy gave us a clear mandate--a man on the moon in this decade. It was a clear goal that everyone could rally behind. But ever since we achieved it, we have not been sure what the next stage should be. We need a new vision that is equally clear." And now we are seeing one that *is* equally clear, but it is not ours.

Mr. Nicodemus puts transparencies on the screen of crystal-clear and very long-term Japanese plans to increase satellite launches, develop a solid infrastructure for manned space flights, participate with the U.S., Russia, and France in building the space station, build earth-orbiting hotels and a lunar outpost by 2020, a full-fledged lunar-orbiting hotel by 2030 (*by now, murmurs of discontent are heard around the room--why should it be them, and not us?*), an outpost on Mars and a Mars orbiting hotel by 2040, and a colony on Mars by 2050.¹ The key to these accomplishments, as the Japanese see it, is

the development of a horizontal lift-off, single-stage-to-orbit (SSTO) space plane. The long-term payoff they see is in tourism--according to Mr. Nicodemus, the U.S. Congressional Office of Technology Assessment has estimated that there could be as many as one million passengers to space per year by 2035. To this American aerospace audience, the Japanese plans seems very far-fetched, almost fantastical. What makes them uncomfortable is that, according to our speaker, the Japanese see it as do-able. Why? It is not the Japanese government that is planning such moves but four or five private corporations--Taisei Construction, Obayashi, Shimuzu, Nippon. Their combined capabilities are indicated by the fact that Shimuzu alone has been showing an annual profit of 7 billion dollars *in addition to* its large capital reserves. As Ken pointed out to me later on in the hall:

The Japanese have no problem. They go into the aerospace industry, and they want to work a particular problem, and they get 125 companies cooperating to do this. And that's what we're competing against. We consider ourselves extremely fortunate if we can get *three* aerospace companies to work together on something. Now part of it has to do with the laws on monopoly, anti-trust, etcetera [and part with our own focus on competition]...we should decide our own destiny on what we think is right, but we should be very much aware of what's going on in the competitive and cooperative global aerospace arena.

The audience is restive. Nicodemus has touched on the issue that is presently most painful to space planners in the aerospace industry--government vs. private funding. The American space program has, up to now, been almost entirely funded by the American government, and even privately held American aerospace corporations have been heavily dependent on government spending as well. This dependence--profitable in the past but extremely *unprofitable* since the end of the Cold War resulted in massive cuts in the defense budget--has kept them from being competitive in the private sector. (Someone from Boeing noted out loud that Boeing's idea of marketing used to consist of the huge piles of paper necessary to meet federal requirements.) Such companies are looking for an end to the painful layoffs and 'downsizings' they were forced to undergo by government budget cuts in the late 80s. They are finding some of that in the development of new commercial products such as Boeing's 777 airplane, and they hope to find a great deal more of it in the commercial development and exploitation of outer space.

Like the Japanese, American space planners see the key to this market as the development of *reusable launch vehicles* (RLVs), most especially the *single-stage-to-orbit* (SSTO) kind. SSTOs are rockets or planes that take off, go into

orbit, re-enter the atmosphere, and land all by themselves (most current launch vehicles, including the ones that carry the shuttle, are huge and costly boosters the size of skinny skyscrapers that fall away and often burn up after launch). Much of the technical workshop that took place on the day before the conference consisted of presentations by Lockheed and McDonnell Douglas of the design prototypes they have developed for single-stage-to-orbit rockets and planes.

McDonnell Douglas' research seemed promising--their engineers had actually designed and built a prototype rocket--the Delta Clipper--that was one-third scale. They had made it fire, lift off, go up in the air a mile or so, move over sideways, and land exactly where they told it to. (*Sigh*--it seems so primitive, compared to the Enterprise.) Likewise, the report from the Lockheed Skunk Works engineer showed promise. He displayed designs for a space plane that could take off and land horizontally, like a regular airplane. Engineers from both companies were excited. Just give us some money and set us free, they said, and we'll have a viable SSTO in two years.

I was confused. It seemed so simple. What was the problem? If everyone could agree that the SSTO was so important, if the engineers were so sure they could build it, then why didn't McDonnell Douglas or Lockheed just go ahead and develop it? Willing to reveal my ignorance, I raised my hand and asked. And the engineer at the podium answered me with the myth of the government as (failed) Creator: "Well, it the government's fault--they won't put up the money we need to develop this thing." Since it was my first day of exposure to this story, I didn't hear it as true, and so I asked, "Why do you need to wait on the government?" A brief silence fell. Aware that I had either touched a nerve or asked an incredibly stupid question (it turned out to be both), I let the public discussion go on, and drifted to the back of the room where I found a friendly engineer from Boeing, and demanded to know what everyone else seemed to already know.

DAVIS-FLOYD: So McDonnell Douglas is sitting there with this rocket that works, but they can't launch it, or do anything with it, just because they don't have enough money.

McDonnell Douglas engineer: That's it!

DAVIS-FLOYD: But why can't the company itself just go ahead and do it? Why do they have to wait for government?

Engineer: Well, if you noticed in a subsequent presentation, I think Lockheed guesstimated the cost of fully developing the technologies--now theirs was a little different--

DAVIS-FLOYD: Six billion.

Engineer: So, you gotta front six billion dollars for very high risk, and what's the payoff? Maybe the government is going to buy a few of these?

DAVIS-FLOYD: Why would you sell them to the government? Why wouldn't you just market them directly to industry and the international community that is supposedly so desperately waiting for additional launch capacity?

Engineer (*with finality*): The numbers don't add up.

DAVIS-FLOYD: Ah.

That "Ah" was designed only to cover up the fact that I didn't have the faintest idea what he was talking about--I had by then noticed the people who primarily told stories with numbers, engineers and businessmen alike, found it difficult to explain punchlines like "the numbers don't add up" to someone who does not speak that language. By the following day, I had a much better grasp of things, so I asked my questions again, this time of a manager from Boeing. He answered:

Gary Lee: The bottom line is that the return on the investment in commercial space, at least for the next foreseeable future, up to the year 2025 or so, is that *you will not be able to make a profit for the investment*. It's no different than other start-up industries. What spurs the investment for startup industry has been government. The government, by their upfront investment to offset the costs--not that the government paid the whole thing, but it offset some of the costs and risks--well, by offsetting the costs, they lower the risk, such that venture capitalists and the private industry will invest to build the industry, and over time the markets develop. That's where you need outside contributions. Now there are different ways to get that--tax incentives, outright participation by government agencies like NASA, or go out of this country and get it from other countries.

The frustration of these engineers with the lack of government support for commercial space activities was palpable, and was compounded by their awareness that their European and Japanese competitors have been enjoying governmental support that is not available to the American aerospace industry:

Dave Scruggs: It's actually a very interesting question in our society, about, you know we don't have what's called an industrial policy. European countries, Japan--the government works with industry to create a long term plan called an industrial policy, so that industries can target their investments in particular ways. They'll line up banks--I mean, there's a public/private partnership for the betterment of both. Norway used to call it Norway Incorporated, or Germany Incorporated. We don't have a concept like that. And the idea of government doing something with business is a no-no.

Engineer: Now if you look at what the Europeans did, their ESA and the Ariane is quite a bit subsidized by the government. See it doesn't look like that on the surface, but it is, very much so. They're not as up front as we are about it here. So that's where the numbers come in, from a commercial point of view. I forget what the ratio is, you know--you spend a dollar, you gotta make ten in however many years. If that equation doesn't add up, no company in its right mind would invest a single dollar in it. I have trouble convincing my management to invest a couple of hundred K to do some study because I see 20 million dollars worth of business out there. And that's just a little one. So, that kind of gives you an idea.

DAVIS-FLOYD: It does.

Engineer: That's why it's difficult, especially when the things cost so much. If they weren't as costly to develop, and the risk wasn't as high--because you're risking a lot of failure along the way. That's the other issue--you're risking failure and having to change direction and redesign it a different way, so every time you do this redesign thing, it costs money, and that's the problem. And that's why we need the government to--it doesn't even need to be *fully* subsidized. I think everybody will agree to that. But it needs to be *partially* subsidized to some degree, which requires vision, which stems back to where the stories begin--

DAVIS-FLOYD: --back to why Ken is doing all of this.

Engineer: Yeah, exactly!

THE EARTH AS A CYBORG?

In the beginning, Mother Earth and Father Sky mated. Numerous were their offspring as the stars in the sky. Last to be born were humans, who could not be content to exist but desired to become Creators themselves. Envyng the stars with which Father Sky adorned himself at night, these humans mated their minds and hands with the technologies they developed. Eventually they gave birth to hundreds of little satellite babies, and flung them up into Father Sky. But the humans couldn't throw very hard, so the shining satellite babies didn't go very high. "This is good," said the humans. "Being nearer, they will shine all the brighter." Afraid that Father Sky would become jealous of her grandchildren and try to steal them for himself, Mother Earth enveloped them in a protective transparent blanket, and there they stayed, circling Her in homage, and carrying on long buzzing conversations with Her, with each other, and with their human parents. And for a time, all was well. The satellite babies shone brightly, adorning Mother Earth like a diamond necklace, and complementing the

stars that Father Sky had sewn onto the black cape he wore at night. But the humans, wishing to eclipse Father Sky completely, kept on giving birth to more and more satellite babies, and still more, until so many were circling the Earth that She was never dark, and could not sleep at night any more. And their buzzing conversation got louder and louder until it became a terrible, unrelenting noise that drove Mother Earth and her human children to distraction. Then Mother Earth, frowning in anger, pulled tight her enveloping blanket, tighter and tighter, until all the noisy satellite babies crashed into each other, and were silenced and darkened forever. And then She rested, and thought to herself, "All is well." But the very next day, humans started giving birth to satellites again....

So went my dreams on that first SATWG night. The next morning, I started asking how many satellites are presently in orbit all together. The guys I asked looked at me funny, because that is not the kind of question aerospace engineers often ask. Nobody knew exactly, but finally at the MIT/Draper meeting I was given the following information about launches planned for this decade:

Communications satellites: Ellipso (MCHI) 20

Odyssey (TRW) 20

Globalstar (Lora) 48

Iridium (Motorola and Sprint) 66

Teledesic (Gates and the cable companies) 840

That makes 994 communications satellites either in orbit now, or soon to be. Add in new telecommunication plans being made by Hughes and Lockheed, and it turns out that the total number of communication satellites in orbit within 8 years will be 1500 (not to mention the weather, earth monitoring, and spy satellites either in orbit now or soon to be launched).

And what will all these satellites do? They will ensure that anyone with a cellular phone can call anyone else, anywhere in the world, through the interaction of signals bounced between satellites and terrestrial systems. They will let somebody in the middle of the Amazon pinpoint her exact location on the map on her PC, or, as in the commercial, send a fax from the beach. They will allow any and every TV station to send a clear signal through their very own satellite system, and any home anywhere to receive it. They already track weather patterns with high efficiency, and take extraordinarily

detailed photographs of toxic waste dumps, soil erosion patterns, and the effects of acid rain, not to mention of the armaments, military training sites, aircraft capabilities etc. of other nations and of terrorist groups.

Then I discovered that, including satellites, there are 7000 objects bigger than 10 centimeters in low earth orbit that are presently being tracked by the North American Aerospace Defense Command. So I started to wonder, how many satellites *can* be tracked? And how many would fit in LEO before they start running into each other? No one could give me a clear answer about that--it depends on type and altitude of orbit, etc.--but the overall message was, in effect, the sky's the limit--they were talking *tens of thousands*. And then I understood. Here was a practically limitless market for commercial expansion, a real potential boon to an aerospace industry that had been in crisis and shock for the last half-decade. Right now it's only a short story, but it could well turn into a techno-human saga of both mythic and epic proportions.

I woke up that night dreaming about the planet ringed by thousands and thousands and thousands of satellites, all sucking information up from the earth, zinging that information back and forth to each other, and beaming it back down. My American Heritage Dictionary defines symbiosis as "a close, prolonged association between two or more different organisms of different species that may, but does not necessarily, benefit each member." If a cyborg is a techno-organic system, a symbiotic fusion of organism and machine, then I believe that the system created by the organic earth orbited by technological artifacts and in constant interaction with those artifacts is a cyborg--and that is a happening thing which may, or may not, benefit each member.

There is much that is positive in this symbiotic fusion. For example, warnings of weather shifts can save thousands of lives. Earth monitoring satellites are showing us extremely detailed and impressive photographs of the environmental degradation that is only visible in its full ugliness from way up high. We can see the effects of the toxins leaking out of the barrels near Niagara, the massive soil erosion of the Everglades, the silt pileup in the Mississippi Delta, the changes in ocean color from pollution. Such information is enormously useful to environmentalists, to legislators, to all those who are trying to get us to clean ourselves up. Communications satellites increase human contact--it will surely be useful to reach out and touch someone, anyone, anywhere on a cellphone--it may even give rise to ads reminding us that we are all cybernetically connected in the vast web of technolife. And TV broadcasts--well, I leave it to you to decide whether they are useful. In this limitless market, the opportunities for profit, for jobs, for the continued growth of our service- and information-based economy, are truly awesome.

But what about the dangers in those cyborgian "dangerous possibilities"? At SATWG meetings, I hear only unreflexive enthusiasm about the good things that are coming from this technogrowth. The only price these engineers and industry leaders see that will have to be paid is the cost of developing new and more efficient launch vehicles to compete for market share with the Russians, the Europeans, the Chinese, and the Japanese. This price is so enormous--up to \$15 billion to develop one new reusable rocket--that the government is not willing to fund the development of the needed launch capability, and no one company is capable of doing so. Consequently, at SATWG meetings, there is much discussion about how to share that price between industry and government, and even between nations.

What has never been discussed at SATWG meetings is the other price--the environmental price. No one asks what will be the effects on humans, animals, the ecosystem of vastly increasing the number of satellite signal waves passing through our bodies, through our food, through the body of the planet. No one proposes studies on what effects the ever-increasing number of rockets taking off to launch those satellites might have on the ozone layer every time they punch a hole through it. What about the exhaust chemicals? The space debris? Instead, they talk about poking more and more holes--they want to add to the satellites in orbit (and to the thousands of pieces of space trash also in orbit), passenger vehicles so tourists can take a spin into outer space at \$50,000 a pop, planes that can circle the globe in two hours by penetrating to outer space, going halfway around the world, penetrating the atmosphere again, then landing.

Of cyborgs and cyborgification, Donna Haraway says that without being blind to the dangers, one is freed to explore the possibilities. It seems quite clear, at least for now, that the limits to the cyborgification of humans and the planet we inhabit will not come from the technology. Every time I asked a techie at Motorola, at Draper, at Johnson Space Center, "Can we really send faxes from the beach, make watches into phones, build launch vehicles that are safe, fast, and cheap, put a hotel into low earth orbit? What are the limits to this technology?" I always got the same answer: "There are no limits. We can do anything." This then is the myth of the techies and the engineers, the myth of unlimited technological transcendence of natural and planetary bounds.

All they need to enact this myth in myriad forms is unlimited money, which they don't have. Agreement was unanimous that 15 billion dollars is simply too much for any one company to put up on an SSTO, especially given the risk and the low initial return--the fact that "the numbers don't add up." Interested to see what would happen if I pushed the envelope on this one, I asked the guy from Boeing, "How much did it cost to build the Triple 7?" "About \$7 billion." "Well, if Boeing can do that, why can't it put up \$15 billion to build a rocket?" "It's just too much of a risk--no one company has the

cash flow to handle that high of an initial investment." "Well, then," I said, "How about a consortium? Why don't Lockheed and McDonnell Douglas and Boeing get together and do it?" "Well," he said patiently, smiling at my naiveté, "Because we're competitors, and consortia just don't work."

COMPETITION AND COOPERATION: OLD PARADIGMS AND NEW

There it was, once again, the competition myth, the capitalist story that charts reality in the national and international business world, including aerospace. As below, so above. Just as Lockheed and Boeing compete nationally, so do American companies compete with the French, the Russians, and the Japanese. Starting at that Round Table on Day One, I kept hearing, from these scions of industry, that America had to be Number One. As upsetting to them as the crystal clarity and the boldness of Japan's long term plans was the Russian responsiveness to market need. Right now, to launch a satellite in the U.S. one must book with, say McDonnell-Douglas or Lockheed three to four years in advance, deliver the satellite to the shuttle launch site several weeks prior to launch, and pay an exorbitant sum between \$60 and \$100 million. In contrast, one can call up the Russians and say, "I have a satellite I want to launch. They will say, "Fine. That will be \$500,000. When you are ready, please give us 24 hours notice, and bring your payload to us six hours before launch. And would you prefer a small, medium, or large rocket?"

This Russian market responsiveness was most upsetting to the American businessmen around the table at this D.C. "Executive Panel Session." They easily agreed, since we were still the world market leaders in technology development and sales, and since our government-funded space program was by far the largest of any other country, that we should be Number One in space commercialization as well. This of course is merely a corollary of the Great American Myth that we are/should be Number One in everything, including the world.

It's un-American, I know, but I found myself resisting the extension of this Great American Myth to space. It seemed to me that it would be a lot cheaper and more efficient to team up with Japanese, Russian, and French space industries--as we already have on the space station (a non-commercial venture)--than to compete with them. So I raised my hand and asked, "Why? Why do we have to be Number One? Why can't we work in partnership with ESA, Japan, and Russia to commercialize outer space?" Another brief silence fell. This time I was sure I had touched a nerve, a tension in their philosophy between cooperation and competition, which Ken Cox glosses as "*cooperation within competitive bounds*" (the

business buzzword is “coopetition”). This trope plays out at international and national levels, running like a literary connective thread between all four of the SATWG meetings I attended.

COX: I coined the phrase "We need to learn how to cooperate with competitive boundaries" because, while it's terribly important to recognize the competitiveness of this country, how the market system works, there are places where it's of mutual benefit to cooperate.

Not only do cooperation and sharing form a major part of SATWG's organizational ethos, but also the official theme of this Washington conference was *"A Team USA Approach to Global Space Commerce."* So my question was not entirely inappropriate--all I was asking was for them to consider the expanded possibility of a Team *World* Approach to Global Space Commerce, to consider operating exclusively out of a partnership model instead of a competition model--at least until a full and viable infrastructure gets built. In so doing, I played right into Ken's corner; his personal ethos is strongly oriented toward sharing and cooperation, his personal story is increasingly a New Age/new paradigm story, and one of his agendas for SATWG is to subtly move the whole group in that direction.² To this end, he regularly invites to SATWG meetings guests who share his new paradigm views, like the D.C. policy analyst who made me feel right at home by bringing Darwin into the competition trope:

Conversation at lunch with a D.C. policy analyst invited to the meetings by COX:

POLICY ANALYST: When you have the advantages of being Number One, and you've dominated the world since the end of the Second World War, it's very hard to give that position up. It's like the return of Social Darwinism. But Darwin's description of the evolution of species didn't only talk about conflict and competition--there wouldn't be any competition if there wasn't also cooperation. And Darwin was very strong on cooperation. To use a biological science paradigm in the social sciences, you have to take the complete picture. And one thing is that aggressive capitalism, which is obviously very much a part of our own national ideology, doesn't take into account cooperation. It's essentially competition--it's conflict, it's the elimination of the weaker part. And that's totally inconsistent with even *Darwin*. I think it's the Reagan and Bush period that brought this so much to the fore, and we need to come back and say, well, it has to be a bit more balanced--it can't be only competition, because there has to be also a sense of cooperation on both global and regional scales.

Along with partnership and cooperation, the “new paradigm” discourse in business honors visions and visionaries as essential to keeping a company’s creative juices flowing. New paradigm proponents cluck their tongues and shake their heads when a speaker makes an “old paradigm” presentation--that is, one that is narrow-minded, hierarchical, smacking of bureaucracy, and lacking in an overarching vision. Thus Ken’s own discourse, which is truly visionary, is appreciated by the members of SATWG/SIIG. To be sure, to many of these industry reps, a “vision” is no more than a long range plan. But to Ken, a vision is transcendent, and he manages to introduce much of that sense of the word into their discussions and policy statements, not to mention into the way that they think. His vision statements, which he revises every six months, introduce every SATWG meeting; the “parting thought” Ken placed at the end of the manual of handouts from the Phoenix meeting in May 1994 was *“What are the possibilities for an innovative, collaborative framework for working TOGETHER toward our future in space?”*

COX: Cultural change is very difficult. We really are talking about *new paradigms*. My feelings are that we can get together in aerospace and do some of these partnerships, collaboration, *community-building*, as well...I call it *soft technology*--technology associated with people and community. Most technology we talk about is hard technology, it's technology to build objects and things. What we're coming to realize is that hard technology itself is not the whole problem. People working together--capturing the meaning and creativity of our people is as important as the hard technology...We must show young people--and ourselves--that there's more than competition, and that here are the benefits of cooperation, here are the benefits of community.

DAVIS-FLOYD: How did you come to understand that?

COX: I think probably when my daughter had an alcohol problem--she was in high school, and our entire family had to deal with it, and it was very good for me. It was a typical case where we went into to fix *her* problem, but the treatment center absolutely required that everyone in the family be involved. That was a transformational experience for me, because I *had* to deal with me.

[Later, at my wife Kay’s urging, she and I went to New Mexico to continue that process. With a group, we] went out to the Chaco Mountains, there were about 30 of us, started on Thursday, finished on Sunday. It was wilderness but it was sacred ground. The first time I went, we were to build banners. I had never built my own banner before, and what made it interesting was that the whole idea of building the banner was to celebrate the changes in

your life in the past 12 months, so it required thoughtful reflection. Not good or bad, just changes. And so I constructed the banner, I just jumped right in, I loved it. So when we went to the long dance, there was some fasting, and we built a dance circle on this beautiful barren land, we built a sweat lodge from scratch, and then the ceremony was to have a sweat lodge and then on sundown on Saturday, we were on top of a hill, we went to the dance circle we had built at the bottom, and all marched down with our banners. The dance started at sundown and lasted all night--till the sun came up Sunday morning....And when we finished, we came up and had a sweat lodge at the end--it was a marvelous experience. I've done it twice.

And I've been involved in other stuff--some shamanic work, gotten into some body work, was rolfed--interesting experience! I've done some Reichian work. A lot of it is just working on myself, from a bodywork standpoint, from getting in touch with the feelings, or whatever--the spiritual side. My wife has really been instrumental in encouraging me to do all of these things. What's happened is that I've done all this like--yeah, I go work at NASA on the space program, but this is where I'm *working*.

DAVIS-FLOYD: In other words, you did it all in a separate way, separate from your work with NASA.

COX: Yes, I did it all in a separate way.

DAVIS-FLOYD: So then when did you start bringing all that *into* your work with NASA?

COX: Hmm. In 1990 when we started SATWG.

Besides its general philosophical emphasis on cooperation, community, and vision, the "new paradigm" approach focuses on the importance of paying attention to process, with specific implications for how business gets done:

Conversation with Mike Ryan, business professor:

DAVIS-FLOYD: I am getting a feel for what "paradigm" means to these SATWG guys, why they are enthusiastic about "new paradigm" stuff and disparaging of "old paradigm stuff." For example, a NASA systems analyst had been investigating the difference between government and private industry work, to figure out why everything NASA contracted for seemed to cost so much. He made a personal visit to a particular small aerospace design firm which, he had discovered, manufactured a product which it sold both to NASA and to private companies, but for which it charged NASA four times as much. When he asked about the reasons for this cost discrepancy, he was shown a stack of paper about an inch high, which constituted all the paperwork involved in selling to private industry. Then he

was shown an entire drawer of a large filing cabinet, which was completely filled with the paperwork involved in selling the same product to NASA!

MIKE RYAN: I researched this issue in another context, and found that the Russians put up many many many more rockets than we do, with about 1200 people. That's all it takes them to put up a launch--twelve hundred people. NASA takes six or seven thousand people to put up a shuttle launch.

DAVIS-FLOYD: Oh my!

MIKE RYAN: And many years they don't do anything, and you're still paying those people to sit around and be ready to launch. Is the problem becoming clearer?

Part of this new paradigm story about streamlined processes, minimal bureaucracy, and increased efficiency involves a transformation in thinking about access to outer space. Its clearest articulation came from storyteller *par excellence* Frank White, author of several science fiction books and of [The Overview Effect](#), the influential book that detailed the profound transformations in consciousness experienced by the Apollo astronauts as they gazed at the earth from afar--and later by the general public upon seeing the famous photographs of the earth taken from outer space, in which in which no national boundaries are visible, only a swirling blue-green continuum, one world, the fragile ecosphere.³ Frank's new story is that the next step is for U.S. space policy to shift "from high cost/low access to low cost/high access." In other words, the way it has been, only a few highly trained individuals have had access to space travel, at enormously high prices paid by the government; in order to open up space to commerce and free enterprise, the cost per pound must come down and a wide range of people must have access to low earth orbit, including space tourists, "space entrepreneurs," and "space settlers."

Frank's articulation of this "new paradigm for space" which he presented in full at both the Washington and the Phoenix meetings, is heartily endorsed by SATWG members. I heard Frank's language picked up and used repeatedly:

Jon Brown, Eagle Engineering: Frank's paradigm is well stated. His point on the need for change from "high cost, low access to low cost, high access" for space is key. We believe it is the government's responsibility to do things that cannot or will not be done by industry and then allow industry to move into the lead to convert the process into a money-making commercial industry. The government needs to think about enabling capabilities rather than executing big programs.

DAVIS-FLOYD: You said that the presentations yesterday were out of the "old paradigm"--they were only about "how do we make a newer, bigger, better rocket." So how would the "new paradigm" be different?

Rockwell engineer: Instead of high cost, low access, the goal is low cost, high access, with the real operative thing being high access. It's important to make space available to as many people as possible so that as many as can will have the benefit....The paradigm shift in how you go about doing that is gonna be shifting away from government-driven to industry consortium/cooperative partnerships. It's a different paradigm in the sense that it's more industry-led, with the government coaching, facilitating, rather than government-led, government-funded, always looking to the government for leadership.

One meeting participant in particular had a unique perspective on "low cost/high access":

Dennis Wood: They are trying to get at potential customers. If they got down to 100 dollars a pound I'd go on a crash diet, and try to get a grant to go up there!

WHY BOTHER WITH SPACE? : "THE VISION THING"

After four days at the D.C. meeting--four days of intense interaction with aerospace engineers and managers, intense effort to learn their language and understand their stories, I found myself accompanying them to a reception on Capitol Hill, to watch them "engage members of Congress in a dialogue" (government organizations like NASA and its offshoots are forbidden to lobby) about the potential benefits of space commerce. As one of them put it:

We need to build a presentation that will convince even an inner-city black congresswoman that we ought to put human beings on Mars. If we can do that, we can convince anybody else.

They felt that this convincing was needed because they were nervous. The space station had survived by the thinnest of margins--two votes the other way could have killed it. The Challenger disaster had severely shaken public enthusiasm for the space program, and continuing cost overruns had eroded congressional support. There are many who feel that the money that is feeding NASA would be far better spent on feeding the homeless--an attitude, I discovered, that was shared by the wife of one of the prime movers at SATWG. On the metro, as we returned from the Capitol Hill reception, she confided to me that she really didn't like the space program much at all, that she thought that it was far more important to stay focused right here on earth. A dedicated stay-at-home mom with a 2 1/2 year old and a 10 year old, she thinks that the

billions of dollars spent on space would be better spent on prenatal care and taking care of mothers and babies. Speaking enthusiastically about how much energy she puts into raising her own children, she expressed her deep belief in the importance of the mother's presence, and of never denying a child's legitimate needs. I complimented her:

DAVIS-FLOYD: Well, when you raise babies like that, they grow up not having very many wants and needs, because they're secure individuals, not needy and grabbing from the outer environment all the time because they are already fulfilled from the inside.

CATHY LOWE (a pseudonym): How is it that you understand that? So many people think that meeting all a child's needs will spoil them.

DAVIS-FLOYD: Because I'm a mom too--I'm raising two kids, and I've watched many other people raise their kids, and I know from experience that well-nurtured children do not have that void inside them that makes them try to suck their environment dry to satisfy needs that never got satisfied when they were kids. That's what drives the consumer society, of course, but it's not healthy. Your way would lead us away from that sort sort of insatiable consumerism and toward a happier and more sustainable way of living.

CATHY LOWE: Well, that's the idea, that's exactly what I'm trying to do. I'm very much there for my daughter whenever she needs me, and I think that's where we ought to be focusing our energies, and putting our money, not out there in space somewhere. If we take better care of our children, they will take better care of the earth.

To this mother's story, a story told in different forms by many others, including black congresswomen from the inner city, Ken responds:

One, I believe NASA would be miles ahead if they would help make money in space so that we could say the issue is not "Do I have one dollar of federal expenditure this year and do I spend it in space, or do I spend it for the homeless?" I believe that the government should take the role of helping to let money be generated in space, so that there is a balance between bringing money in and spending money....I think that if all NASA does in space is to continue the old way...the general public will not feel that one dollar is worth it. Because much that we do in space has little or no value to the average citizen.

But most importantly, I believe that anyone with a sense of evolutionary history will understand that any organization, a government organization, an educational organization, the Roman Empire--I don't care--any

organization that spends an excessive amount of its resources looking inward is doomed to decay. There must be an appropriate balance of outward-looking frontier efforts. I believe the real question is not one dollar for NASA versus one dollar for the homeless. We must have some appropriate way in which to allocate our resources for outward as well as inward. The issue is, "Is it 90% inward and 10% outward, or 95% inward and 5% outward?" But to make it 100% inward and 0% outward is absolutely, in my judgment, in effect saying that this country will decay....Entropy says that you're either growing or you're declining--you are either spiraling outward or you are spiraling inward. There is no such thing as a perfect circle with just "keep going the way we're going and everything doesn't grow or diminish." That isn't the way life really works. It isn't the way energy works.... You have choices and in this case, the choices are long range choices, they're almost like evolutionary choices. People can say, "My problems are so severe I've got to spend all my time problem-solving," but you must have some relationship between solving problems and reaching out to new opportunities.

Now, the majority of the American people [need to] understand we're talking about the right ratio, not spend a lot for space or spend nothing. Education is needed, but...I really believe the most important thing we could do for the space program is to lay out choices in a systems-oriented sense, in long-range perspective, and let the American people decide...And part of it is, in this country we're in an evolving state ourselves--right today we're in this sort of era where we want services but we don't want to pay for them; we have not yet learned to live within limits.

Is he right? Will feeding a certain percentage of our economic pie to the space program help us to generate money in space, or teach us how to live within sustainable limits, or would 100% indeed be better spent here at home? Desire for the transcendence of a clear vision, juxtaposed against the complete irrelevance to human or planetary wellbeing of space tourism and orbiting hotels, haunted me as well. Still on the metro, and pushed by Cathy to articulate my thoughts, I opened my mouth to agree with her, but what came out wasn't what I'd planned. In many publications and presentations over a decade's span, I have spoken out for mothers and babies, for organic childbirth, for holistic health care, and for the environment. So what did I say to this woman who was espousing what no doubt should have been my own position? I told her that I thought that the space program was essential to the future of our species, that help for our technologically-created ecological crisis will come from the technologies we must develop to accomplish space travel--that we had to reach to the stars in order to improve life on earth. I cannot even plead total cooption by the SATWG engineers as my excuse--rather, I

blame it all on Gene Roddenberry, William Shatner, Leonard Nimoy, and Patrick Stewart. Yes, it's true, as you've no doubt noticed--I'm Robbie and I'm a Trekkie. I've seen every single episode *at least* three times, and my personal vision of humans in space is permanently imprinted by Star Trek's ongoing enactment of Roddenberry's vision that space travel will help us improve ourselves, rise above our imperfections to create an earth without war, pollution, gender hierarchies, or capitalist greed, and that space technologies will ultimately be employed back on earth to solve our physical and environmental problems.

The next day I found myself articulating this vision to Mark Craig, a man Ken introduced me to as "the person within NASA that has the responsibility to lay out the charter for humans in outer space. That is his job. He needs help from all of us. " Mark had asked me what I thought about the future of humans in space, and I got a little carried away (Roddenberry's fault):

DAVIS-FLOYD: The real question is not "What is the future of humans in space?" but "What is the future of humans?"

MARK CRAIG: Yes, of course.

DAVIS-FLOYD: What I don't see addressed in these meetings is a sense of NASA's *necessity* to a successful future for the species. If you look at evolution, you'll see that there have been other species of hominids that died off. But before they did, they were around for a million years or more. We've only been around as *homo sapiens* for some 200,000 years, and as *homo sapiens sapiens*, for some 80,000 years. We're an evolutionary twig, massively dependent on a fragile global economy, a diminishing water supply, a limited number of foods, and a threatened ecosystem. There's absolutely no guarantee that we're going to make it. The planet will survive, but we may not, because we are so busy poisoning our own environmental niches. Having created such a mess over the past 400 years of technological development, we will be forced to rely on further technological development to clean it up, as well as to survive in the meantime. I understand how profoundly the space program drives technological development. And I truly believe that NASA's role in creating new possibilities for the future of the species is critical.

MARK CRAIG: Yeah. That's a broader view--I mean, we all recognize that, we all realize it. We don't articulate it as clearly as you do. But it's there, it's what drives us...We're engineers, we're not used to articulating inner feelings. That's part of the culture change we need to go through, is to start getting some of this emotion out. We're all numbers and formulas...

DAVIS-FLOYD: I wondered, is it just that these guys have no environmental consciousness at all? But then you talk to them individually, and they do have it, it's just that they don't use the language, I guess, or feel the feelings, like you were saying.

MARK CRAIG: Well we *feel* them, we just don't say them.

Yet juxtaposed against the potential transcendence buried within the SATWG vision--and my own--is a fundamental truth: most Trekkies, and most engineers, just plain want to get humans into outer space because, like Mt. Everest, it's *there*. Period. And we will rationalize that desire in any way we can, from expressing lofty sentiments about the next evolutionary step to crassly commercial justifications:

Representative from Peregrin Properties: Once the international space station is actually completed, and you've got a certified occupancy-type structure, we believe you can move directly to bed and breakfast class hotel-type facilities within a period of five to seven years, and actually be able to confirm hotel reservations, starting in about the year 2012 to 2015, using the technology and hardware developed for the international space station--just modifying it....But, you need to have the RLV [reusable launch vehicle] program to be able to bring down the costs of getting up there, in order to make the economics work.

DAVIS-FLOYD: Do you think that the idea of hotels in space is a compelling one that would generate public support for the space program?

Peregrin Rep: Sure. Absolutely, because one of the things that is most compelling is the view from low earth orbit and the almost transcendental experience that the astronauts have reported on about how your world changes when you've got your face glued to the porthole, and you can actually see Earth, like the I-MAX movies only for real. And that experience should be worth a lot to people who are looking for new and exotic vacations and are willing to spend a lot of money. I mean, it's going to be really expensive. But, uh, we think that there's at least a small market, in the same range as the Antarctic expeditions and the round-the-world cruises and the lease-a-yacht-to-cruise-the-Mediterranean-for-five-weeks-type vacation class. If you can find three to five hundred people a year, worldwide, that would have both the money and the inclination to do it, that's all you need to get started. And, then, you know, it's just like any other technology, once you're on the slope of maturity, you would expect costs to decline rather dramatically, like personal computers or cellphones, or anything else. You know, I mean it's that type of a curve as

opposed to an escalating cost curve that you typically find in real estate projects. So, that's kind of what we're trying to do.

DAVIS-FLOYD: So the taxpayers should fork over billions for the development of a launch infrastructure that will let the very wealthy, and maybe, years later, the middle-class, take a vacation in space? And you find that a compelling vision?

Peregrin rep: Well, maybe not compelling, but certainly appealing.

Yikes! I'm starting to re-think things from Cathy Lowe's point of view. Meanwhile, Gary Lee from Boeing articulated a far more pragmatic kind of vision:

LEE: I see this thing as being crucial, not from a self-serving standpoint but from the standpoint of being one of the infrastructure elements that's gonna make for a prosperous nation--which is gonna come about from a prosperous economy, the jobs that provide a quality lifestyle.

DAVIS-FLOYD: Why do you see this group as crucial?

LEE: I think it's because of the chemistry, the stability of the group to have some vision of how we can obtain that market share in the space industry and yet share in the rewards, and that's crucial--*share*--not hog it, you know like one company running away with it, but really share. I say that because I think the only success in the future is sharing. You can't do it yourself, from the standpoint of someone gets an unnatural share, or greedy--that's kind of frowned upon here, that's not the acceptable practice.

DAVIS-FLOYD: Interesting, it goes back to the days of the robber barons--take all you can get, step on everybody else.

LEE: Now that's not to say we wouldn't want to attempt that! But I think the counterbalance is that it's very difficult to succeed if you are seen as being that.

DAVIS-FLOYD: Why?

LEE: Because I think so much in the area of public opinion, not just within the U.S., but internationally--the bad guy/good guy syndrome is better understood on a wide international level than it has ever been.

Sigh. So much for nobility of spirit in the aerospace industry--it's image, not essence, that still counts. Suffice it to say that SATWG participants in general buy into the Capitalist Myth that the free market, on the ground or in LEO, will

somehow just naturally work out for the greater good of all in the long term, even if in the short term it rapes the environment and enriches only a few. They have an enormous interest in creating ways to make a profit from--watch the language--"the exploitation of space as a commercial resource," but every time I was tempted to decide that they were just capitalist pigs trying to take the worst abuses of our money economy and throw them up into the sky, I would be forced to re-open my mind:

DAVIS-FLOYD: Three hours into that Executive Panel Session roundtable, I found myself getting increasingly upset...all they were talking about was who could make the most money from satellites and orbiting hotels in the future. Not one word about the environment we have to care for in order to *have* a future.

MARK CRAIG: The people at that inner table...They were just operating at a lower level of the Maslow hierarchy--they are down at the survival level right now. They're not able to deal with these higher things. They've all got 'em or they probably wouldn't be in the business, because there's probably not a person there that was in it for the money. I think that what I saw there, the thinly veiled anger, the frustration--that's the way any process of change--it has to go through that stage...you have to recognize that people get rid of hidden agendas by getting these feelings out. Although I had some of same feelings you had--these guys are idiots, they are focusing on *their* tomorrow and not on the real future--it's a stage I think we've got to go through.

DAVIS-FLOYD: Why did you say nobody at that symposium yesterday was in it for the money?

MARK CRAIG: I don't think there was a person there that chose to be in it for the money....The people who choose the profession we're in don't choose it because they have a desire to make money. You just don't choose it that way. And so as you pyramid up in the organization, you never have that motivation. If you did--(*points to an executive*) *he's* making a hundred thousand dollars a year. With his brains and intelligence and what he has accomplished in this industry, he could have gone to Wall Street and been worth half a billion dollars.

DAVIS-FLOYD: I'm glad I asked you, because it would have been all too easy to conclude that their primary motivation was money, since what they were talking about was commercializing space in a very capitalistic kind of way. It sounded like they were just out to make a buck at the taxpayer's expense. And you don't see that as their primary motivation?

MARK CRAIG: I don't think so. In the first place, they don't make anything but their salaries. Some of them have stock options, I'm sure--but that's not their motivation. Their motivation right now is saving their employees. Remember

now, this is what's different in this industry. Our capital is our people. Most of them don't even own the buildings that they operate out of. Rockwell--De Nino doesn't even own the buildings that he works in--they're owned by the government, and all the capital equipment there is owned by the government. So his only capital is the people, so that's what they have to protect. If they lost their people, they lose their only resource, that's all they have.

My concern about the lack of environmental consciousness in SATWG was further alleviated later, when Bob Young, President of Lockheed's Technology Services Group, started talking about outreach from space technologies, especially remote sensing of the earth. He showed topographical maps of the U.S. taken by satellite with a map of the U.S. superimposed--and he did it by season, so that one could see how the crops are harvested, and how the whole picture changes. With stunning effect, he showed the erosion of waterways from satellite photos, dead fish covering the shoreline of a lake polluted by toxic waste, the clearing of the rain forests, the soil erosion that will make New Orleans an island within a few decades, the smoke trail from the oil fires in Kuwait. He showed the border between two countries, one of which encouraged forestation and the other of which did not; the border was a perfectly straight line dividing brown and green. He showed a Russian lake 20 years ago and the same lake today, drastically reduced from irrigation. To illustrate remote sensing technology, he showed a slide of the vanishing of the Everglades from soil erosion through the paved canals and heavy salt water intrusion. And he said, "You can't see any of this from the earth."

I was fascinated that he was offering profound environmental reasons for commercializing space, but couching them in terms to which these engineers could relate. In effect, his environmental story was subtle: "Isn't it incredible what this technology that our payloads are putting in space can do! This is why we need more launch vehicle capacity, to keep doing this and do it more thoroughly and more effectively." He clinched the need for ongoing improvement with slides of resolution per meter: some years ago, each shot encompassed a minimum of 100 meters; now, that's down to 10-30 meters, with astonishing clarity and detail. He spoke of the usefulness of such images and the information they contained to the environmentalists, to legislators, etc. He had everyone's full attention, and I began to understand another story, one which most SATWG attendees insist on--the story that profit is not the only driver, that commercializing outer space will benefit us back on earth in myriad ways. Several aerospace firms print glossy brochures detailing the possibilities: solar farms, nuclear waste disposal in space, rapid global transit in space planes, space-driven technology that spills over into earth-based applications, like the remote fetal monitoring devices being explored at Ames, and the "space-age forceps" (which will be able to measure the degree of force being applied to the baby) being developed at Marshall. The uneasy question is always

whether these benefits are worth the price. While space-driven technologies--including earth-monitoring devices--have proven their worth since the days of Apollo, other commercial space enterprises are iffier. Solar farms in space could only power spacecraft, as beaming that power back to earth would be far too costly; nuclear waste can hypothetically be disposed of in solar orbit, but until access to space becomes truly cheap and easy, launching it would cost more than the plants that produced it; and space planes, while they would get us around the planet in two hours, would use enormous amounts of fuel and poke lots of holes in the atmosphere, with unknown effect. So the potential for transcendence in the aerospace enterprise, the "vision thing," as it is laconically referred to, is a cautionary tale fraught with ambiguity and tension, with ruin as likely an outcome as redemption.

Space from the Second Tier

As we have seen, a major frustration for SATWG/SIIG--the gap between the usefulness of their ideas and their ability to get these ideas implemented--stems from their second-tier status: the managers who regularly come to SATWG meetings from both NASA and industry, while powerful in their companies or agencies, heads of large divisions, are not vice-presidents or presidents. Major corporate decisions are made one or two, and often several, levels above them. Yet it is precisely their mid-level status that makes them so aware of the dysfunctions in the NASA/aerospace industry relationship: these dysfunctions impede their work on an often daily basis.

Thus, in addition to the larger government/industry, competition/collaboration tensions that define SATWG's field of possible futures, SATWG participants feel an internal tension over which story the group wants to tell about itself. Some wish to maintain the information-sharing, purely technical focus under which the group was originally chartered; others want to continue to expand that focus into the larger arena of policy-making because they do not see the necessary steps being taken by those who are actually in charge. The first D.C. meeting, which was primarily focused on the larger picture, generated concern among some SATWG members that the original technical focus of the group was being lost:

DAVE SCRUGGS: You've got people who are technologically trained who came in on the basis of avionics. And they don't feel that they are very comfortable in the policy arena. They don't feel that they have a mandate from their companies to do this. And the word they get from the companies is, look, you're on the technical side of this. If we want to influence policy, we pay people in Washington to do that. We should send other people to this group if that's what you're doing.

In response, the first day of the Phoenix meeting (May 1994) was set up as an all-day futures planning workshop in which these tensions were discussed at length and ultimately resolved:

SCRUGGS: One of the things they concluded was that they wanted to pay more attention to the technological basis of the original charter--that it had fallen somewhat into disrepute--and that at the same time they wanted to move ahead in formulating themselves in more effective ways to influence policy, which might mean that they should have an additional new special interest group around influencing policy.

DAVIS-FLOYD: So they started out technological and they ended up political.

TOM NICODEMUS: Of course. Taking a hard look at technology doesn't do you any good if you don't have a market potential for it. So they've *got* to stay on that other course.

Trying to stay on that other course, a group of SATWG/SIIG leaders planned a careful presentation of specific findings and recommendations to give to General Dailey, the Acting Deputy Administrator of NASA, second in command under Dan Goldin. Dailey had given a talk on the last day of the first SATWG Washington meeting (his topic was "Reinventing NASA") during which he expressed strong interest in SATWG's work and asked that he be informed of the results. SATWG working groups formulated a number of specific policy recommendations that they hoped would be incorporated into the massive restructuring of NASA that was already in progress. Several appointments with Dailey were scheduled, only to be cancelled by his staff.

In the spring of 1994 in Washington D.C., the National Space Society held a first-tier roundtable meeting on reusable launch systems. NASA head Dan Goldin was present, as were the CEOs of the major aerospace companies. Ken Cox was invited to come and sit in the outer circle, which meant that he could be present and observe, but not speak. Ken tells me that the consensus of this meeting was that government will absolutely not foot the bill for building the needed infrastructure, that industry alone cannot, and that this first-tier group unanimously concluded that working together is the only way:

Although SATWG's voice was not audible at this roundtable, it is too early for the judgment that Ken's story and/or the stories of SATWG will not be heard at higher levels. Ken's star at Johnson Space Center has been rising. When I began this research in 1993, he was Chief of the Navigation, Control, and Aeronautics Division, a position in which he managed about 100 NASA employees and 300 contractors. Soon I started hearing from other SATWG participants at JSC that Ken is

becoming well known and respected there for his visionary approach. In 1995 he was given the official title of Assistant to the Director of Engineering; unofficially he is working under George Abbey, the director of JSC:

COX: I'm really working for the head of the Center now. It's an interesting relationship--I am being allowed to work up an Outreach Program in its entirety and I love it. I don't have to worry about people coming in every day telling me their problems and asking what they need to do. I've done that, and that's OK, but the Outreach itself has gotten so extensive that the NASA administrator in Washington, Dan Goldin, has taken a personal interest in my work, so that has changed the entire climate of how I'm viewed at the field Center right now....He and I were inducted as Fellows in the AIAA (American Institute of Avionics and Astronautics--the premier professional society for aeronautics and aerospace). And Fellow is the highest organizational thing you can make and they had a big production--a black tie affair. Goldin and I were in line together. And he came over to me and said, "Ken, I really like some of the work you've been doing." There wasn't time for any details.

DAVIS-FLOYD: Does Abbey know that Dan Goldin has taken an interest in your work and that he likes it?

COX: Absolutely.

DAVIS-FLOYD: So what difference does Goldin's support make to you?

COX: I think that it's given me a much freer hand to be innovative and creative--there seem to be fewer barriers to new ideas...If you're trying to align creative energy and to generate energy and so forth, the barriers can just wipe you out, so that's a major statement, actually.

DAVIS-FLOYD: Will that be manifested in some kind of official promotion or some kind of name change for you?

COX: I hope not.

DAVIS-FLOYD: Why?

COX: I want to be on a staff position. I don't want to run 800 people right now. I have absolutely no interest ...

DAVIS-FLOYD: I mean, isn't there some way they could promote you to be right under Abbey but not in charge of people?

COX: Yeah, but it wouldn't make much difference in my operating.

DAVIS-FLOYD: It wouldn't give you a different office or anything?

COX: No.

DAVIS-FLOYD: Are you still in the same office that you were when I went to see you or have you moved?

COX: No, I've moved to Building 1, 9th Floor.

DAVIS-FLOYD: Is there a status hierarchy?

COX: Absolutely.

DAVIS-FLOYD: The higher the better?

COX: Yes.

DAVIS-FLOYD: Is the 9th floor the highest floor?

COX: Yes.

DAVIS-FLOYD: Ken made it to the top, I love it!!

COX: Yeah, but the status doesn't mean that much to me. You gotta understand this, it really doesn't mean that much.

DAVIS-FLOYD: And where are Abbey's offices?

COX: On the 9th floor.

DAVIS-FLOYD: In the same building that you're in?

COX: Yes.

DAVIS-FLOYD: So you're close to him.

COX: Yes.

DAVIS-FLOYD: And where are the offices of the Director of Engineering that you're supposed to be...

COX: Also on the 9th floor.

DAVIS-FLOYD: So all the bigwigs are up there in Building 1, 9th floor. Can I touch you?

COX: Right.

Evolution and Revolution: A Hero's Journey

From his elevated position on the ninth floor of Building 1, Ken is actively crystallizing his futuristic visions and planning policies that can lead to their implementation. Myth, storytelling, and the hero's quest for evolution--ultimately, for interconnectedness--have become ever more salient themes in his current visionary discourse:

COX: It's interesting--I think I've been on a hero's journey. I can feel the various obstacles that have been overcome and the fact that it doesn't end. It has paradoxes in it, myths and mythologies, the whole bit...It has become really,

really obvious to me...that space has a vital role in the evolution of humanity. I feel that more strongly, Robbie, than two years ago when we did our first Washington trip. I mean it is just coming through powerfully.

The two key themes that have come out of [SATWG's and my] work and have been accepted within various elements of the NASA community are: (1) in the future, the government should be involved in nurturing and causing to happen space commerce (making money in space)...it's kind of like throwing seeds out and making sure you water them right and the sun comes down and you carefully tend to them; and (2) space exploration--what most Americans envision that the space program is about. Now making money in space and space exploration are interconnected. They are not, do I do one or do I do the other...the American public needs choices as to how much money should we invest, how do we do it, what can we afford? But the truth is we should make a conscious decision to do them together, as opposed to blundering into not supporting either and then later waking up and saying, "My God, thirty years ago we should have done something." So the theme that collectively a shared group of us have developed is "What we really ought to do is take space commerce and space exploration and leverage those potentials on existing programs called Station and Shuttle. We should look at the space station as a unique opportunity to do certain things that will allow us to begin making money in space. We should use the space shuttle in an outreach way, to increase our nation's capabilities, and when the shuttle gets updated to second generation transportation, that's also part of the evolutionary process.

And one other thing about what I would call SATWG evolution...I believe that there needs to be a vision that emphasizes relationships between what we do in civil space, commercial space, and military space. In the last two years, we have begun to unfold and understand that their interconnectedness needs to be cultivated. So throughout all of these first two themes, space commerce and space exploration, is this overriding holistic theme that says that networking and interconnection must be honored, at local, regional, national, and global levels.

DAVIS-FLOYD: Tell me more about SATWG's evolution as you perceive it.

COX: Six years ago, the NASA administrator at that time asked us to look at technology across the NASA centers. I would say the first phase that we went through was integration of the physical sciences. We got various engineers and technologists and operators all talking to each other and that was SATWG--that was the first thing we did with SATWG. The second thing occurred about two years later--we began to have an outreach, which was what I called

integration of the physical sciences and the social sciences....we realized that you cannot just have physical objects--you have got to have relationships and people and culture, so that was the second step. The third step was that we got a key congressional staffer on the House Republican side (who is considered THE expert in the space domain--a whole bunch of congressmen and staffers look to him for leadership). I talked him in to coming to our SATWG meeting four months ago in Huntsville. And he came down for one day and liked the open forum and the open dialogue so well that he stayed two-and-a-half days. And so I call that the beginning of "Now we are integrating the physical sciences, the social sciences and the political system."

And along the way there was another step...we have integrated the physical sciences, social sciences and political system with the business systems bigtime. The NASA employees under Apollo were given a charter to go to the moon, do a technical, skillful project, do it within time constraints, and money didn't matter. And we never, within the NASA culture, really learned the skills of business management. And today, we must have those skills. The political reality is that there is no Apollo for the future for the space program. We must do it within the financial constraints of the country, the political constraints of what people are willing to vote for moneywise. I look at the current economic downturn as a tremendous opportunity for the space program...I am not in the majority of the NASA culture right now, but it's growing.

The fifth step in SATWG's evolution--I'm trying to generalize what we did after we did it. We did not set out to do these things ahead of time. We started on a path, and it unfolded. The fifth thing was integrating the social sciences, the physical sciences, the business systems, the political system with what we're going to now do this month in Washington and that is, we're going to add the ecological aspects. While that's not going to be the theme of the conference, we're going to bring that theme in because the sustainability of the earth and the recognition of Spaceship Earth as an integrated whole is that next step we're taking. You wanted us to get there earlier, Robbie. I understand fully that this is not unique, that this is not discovering something new, but it turns out that this thing has been kind of like peeling an onion--we've just kind of done the things that went with the natural flow. So actually, that's the five things that I see we've kind of gone through with the SATWG process [so far].

DAVIS-FLOYD: How did you gain your current influence on other people's thinking about space outside of SATWG?

COX: Through storytelling! I have used my storytelling pitch, my "Strategic Thinking in Space." I have evolved that pitch, that vision statement, and it got in the hands of influential people... My best way to describe it is that I've

gotten into the fine art of blending *evolution and revolution*, and that in itself is a neat integration function....And what I'm finding out more and more is that what you want to do is *evolve with what you've got*, don't throw it totally away. Revolutionary quantum jumps--you take part of them and blend that into the evolutionary system until you get to the point where everyone's ready to go to the true *revolutionary* system. There is a jump in technology and culture that fits the modern physics, but it's not the one people think. It's really interesting how this evolution-revolution process applies to earth evolution and space evolution both. It was through my telling that story that Dan Goldin found out about my work.

DAVIS-FLOYD: Where does the privatization of the shuttle fit into your evolution/revolution scheme?

COX: The space shuttle is in the process of being some combination of privatized, psuedo-privatized, or commercialized. The important thing is the government per se is going to be getting out of the operations [although at first we will have to pay someone else to do it]....It will be bid...There is a brand new company that has been formed. Lockheed Martin and Rockwell made a new company, and guess what? They call it United Space Alliance...They will be given the job to do shuttle operations, keep it safe, but they will not be receiving, day to day, government direction. So it's not truly commercialization yet, because the money is coming from the government. If it was space commercialization, then it would be private venture capital, you gotta go to Wall Street, you gotta talk someone into putting it up. That's not what we're talking about. So this is kind of a first step toward, it's an evolutionary step toward a more revolutionary "get the government out of operations."

As a storyteller, there's a particular thing I wrote in my vision statement that I really believe in: "The Challenge...we must become a model for blending evolutionary and revolutionary concepts for space by appropriately honoring past experience, realistically understanding the present environment, and creatively aligning the future." I mean it. I really think those words are important. So taking the shuttle program and privatizing it or commercializing it is absolutely, totally the right thing to do if we're going to get on with our evolution of space. Absolutely the right thing to do.

DAVIS-FLOYD: What exactly are your plans for the new JSC outreach program?

COX: With regard to commercial space, I've got enormous interest in JSC's region--the city of Houston, the state of Texas. [I want] to make the City of Houston *the center of excellence for space commerce in low earth orbit*. We're talking to the Houston Chamber of Commerce, the Clearlake development group that tries to get jobs in the

Clearlake area, some of the Aerospace companies, Rice, the University of Houston, A & M....We collectively have come to the conclusion that there are two or three basic technologies for the future that really make sense. One is called nano-technology--making things smaller and smaller and smaller. I am holding a major conference in the Clearlake area one week after the SATWG meeting. The energy involved in this is fantastic. We have gotten the medical center really enthusiastic. It turns out that Texas Instruments in Dallas is on the cutting edge in nanotechnology development. I went over to Rice and found out that of their three strategic planning initiatives for the future...the third one was nano-technology. And I said, "Oh, my God, we've got to get Rice involved in this thing."

So when we went to talk to them, I personally set up the discussion. They are setting up an endowment fund for as many as six to eight full endowed professors in this area for the future. They have dedicated themselves--"This is the way to go!" Boy, we connected. I described this conference, that we wanted them, we understood that they had this strategic plan. And so after about half an hour--and there were about 4 or 5 Rice professors in there, and 4 or 5 NASA types--I said, "Look. This is so obvious. Why haven't Rice and Johnson Space Center connected like this before?" And the answer was, "We tried." And I said, "What?" They said, "We tried five years ago and no one was interested. We tried four years ago and no one was interested. So we quit trying." And I said, "Kings X! This is the new regime. We're on an outreach mission and this is the time to connect."

Nanotechnology is a totally different philosophy. It's a quantum philosophy. Previously, we talk about minimization of propulsion systems, sensors, whatever...make it smaller. Well, this is going a different way. This is going down to the smallest molecular element...and then adding how many you need for the job you want to do. It's a different mind set. It's a different approach. So there will be quantum jumps in being able to sense things and do things in terms of volume, weight, power, energy, what it takes to heat and cool....It has enormous implications for space applications as well as for applications on earth. The medical center is going bananas over it because these things are so small you can embed them in the body. So if you combine biotechnology with nanotechnology, you've got a winner for the future.

And so what we're doing is taking the nanotechnology, the biotechnology, and JSC's access to space and combining them to see what that combination can do for the human presence in space, starting with the shuttle and the space station. We can use this combination to produce things in space, maybe pharmaceuticals, maybe something to do with petrochemicals, maybe something to do with how you grow crystals....Just putting together the

nano-technology conference has caused a lot of these outreach things to happen. They should have happened anyway, but it just needed a triggering edge. And so all of that will be unfolding and we think that the response so far has been so great that we probably will have an annual conference in Houston on nanotechnology with emphasis on space applications...we could wind up with some sort of regional coalition...that really could apply a lot of this to low earth orbit and see where it takes us. The energies and the enthusiasm of all those involved are fantastic.

The issue is, how do you align the energies? And so we're right back to, we need the social, cultural skills of how to get diverse groups working together. Absolutely critical. Absolutely essential. Now in truth, that is part of our entire global challenge on earth. Everything we're doing for the space program is totally analogous, culture-wise, to what we ought to be doing on earth.....it's just like energy. You've got to have a container for the energy. You've got to channel the energy. You've got to remove the blockages, you've got to align the energy....You want the action to take place by the people that know the most about it--the "doers." And you want your vision to be carried out by those who can think at very broad levels and help set the container so the energy is channeled. And so in some ways--and I won't say this in an open NASA lecture--but in some ways we're talking about sacred space in a therapy sense, in a ritual sense. The idea is, when you want to set a vision or whatever, it's setting the container.

Now one thing this country does not do well is to set limits. And since the Earth is finite, setting limits that match earth's sustainability is one of our challenges for the future as we evolve. We can destroy ourselves as well as sustain ourselves and part of going to space and part of what I consider the earth/space sustainability issue is humanity learning how to set appropriate limits. And you darn sure do that when you go up in a spacecraft -- you will have to learn those skills early if you ever intend to live in space as space settlers.

...A space community would have to couple with a lot of other things. For example, you cannot develop space commerce or space community without getting the cost of going up and down cheaper and that's civil space, so you've got to do something in the civil space arena in order to have the commercial space viability once you get up there. [The way it's set up now, space is chopped up into three arenas--one has to do with national security, one has to do with civil space which NASA runs, and one has to do with commerce which industry runs--and their interaction is ignored.] They do interact. My thought on this developing of space community has more taken the viewpoint that we need to leverage on what we've got. What I had before is kind of like "let's take a revolutionary

step." I'm now back to "we need to take an evolutionary step with what we've got, with revolutionary themes and grow it, and then take the revolutionary step."

DAVIS-FLOYD: Your new twin themes of "making Houston the center of excellence for the development of space commerce and low earth orbit," and "making Johnson Space Center the center of strategic development for the evolution of space exploration" sound much more concrete and doable than your earlier proposals. Your earlier emphasis on space communities sounded more "pie in the sky." I'm not sure it was a vision that people could really get their teeth into at JSC, but this seems like it is one.

COX: Yes, much more grounded toward, Where are we now? What does this have to do with what we're doing now?" ...I've got one other thing. I believe that it would be worthwhile to make NASA...a cutting edge agency for creative and innovative organizational change between government, industry, academia and voluntary sectors. I believe that is a proper role of government to look seriously at organizational issues for the future: "What's the role of organizational hierarchies? And what's the role of democracy?" Everybody realizes total hierarchy doesn't work. On the other hand, going totally with a democracy without aligning people, having a focus and having a right direction, big projects just don't get done because individuals work separately. What's needed is the shared group community.

So I believe that in all organizational structures in the future, we're going to have to better understand organizational strategies for community, how communities get formed, get nurtured, develop outreach, and evolve....I think it'd be wonderful to have a government agency at the cutting edge of acknowledging organizational development itself as a creative, unfolding process for the future.

[Also essential is] expansion by dialogue, our ability to learn, and our ability to engage in dialogue. And why that's important is because in my opinion, dialogue between individuals and groups and communities is the one way out of a zero sum game that says "there is fixed energy and if I get some, you have to give it to me." Dialogue creates energy. Dialogue is where three people get together and bring their energy...to the table. When you finish effective dialogue, you have more energy than the sum of the parts. When human beings enter into effective dialogue, they're tapping into some universal source. Now, if I were writing an article, I'd stay away from this, but clearly, we are into spiritual energy.

Besides the integration of future technologies, such as nanotechnologies and biotechnology, there's this third element of technology that I'm wrestling with; I call it noetic technology, taking the term from the Institute of

Noetic Sciences that Ed Mitchell developed. And that gets into consciousness, and how to relate all of the above to the mind and the soul and the spirit. It's all interactive, it's not separated. And I'm trying to develop that into two parts: community development technology in that "outer community sense" and the technology of interpersonal growth. [And a corollary of that is that if anyone has responsibility for a part of a work task or whatever, you must know how it integrates with the whole.] I believe that there's a real trend toward bringing the collective unconsciousness into being through the collective consciousness.

DAVIS-FLOYD: Tell me about the process of change at JSC.

COX: George Abbey, the head of JSC, basically knows we must change, and he's taken some very positive inputs to lay the groundwork and encourage some change at all levels. Now, we'll see how that unfolds because anytime you're in a hierarchical organization, in particularly a government bureaucracy, you can have the head of NASA saying, "I want to do this." And as you walk down under him he's got a staff, and then under him there's people up in Washington and then down to the field centers. As you go from these various elements, you can have a person who wants change and the next level, the person doesn't want change and the level below him wants change, and the next level, no change--so it's not systematic at all. Real change has to take place at all levels. There's a lot of diffusion theory that says, "Anytime you make a paradigm shift, you have to have things being diffused and worked at all levels and when you reach a certain level, it's unstoppable." You only have to get about 19 or 20% of the cultural population in order to have an unstoppable culture change.

DAVIS-FLOYD: I want to return to your take on your "hero's journey" for a moment. Tell me what were you doing at NASA before you got into all this--did your hero's journey start then?

COX: I'd been directing some engineering work in the software, avionics, electronic system areas, since before Apollo. As a matter of fact, I had a major responsibility on Apollo--yeah, I have a story to tell you. I know you love stories.

DAVIS-FLOYD: I love stories!

COX: My story--"Point the Wagon Trains East." I was working at the Martin Company in Denver on some defense missiles in early 1960, and I had gotten a Masters at UT as well as a Bachelor's and I wanted to go back and work on a PhD, so in 1961 I applied to Stanford--that's where I wanted to go to work on a doctorate in engineering, and my professor at UT didn't get my reference in on time, so it wasn't accepted. So needless to say I was pissed off, but I

still wanted to go, so the next year I applied to Stanford again. My wife and I were out--maybe in April or May, and we're driving around the Denver area on a Sunday, and on the car radio, it said, the Manned Spacecraft Center is going to be established in Houston. And I turned to my wife and I said, "I'd like to go to Rice." And she said "Fine." We saved money--she was working. And so I applied to Rice and got accepted, and quit my job--we pointed the wagon trains east. And I didn't even know anybody at NASA. As far as I'm concerned, I made the choice.

So I went to Rice--I got out in less than 3 years with a Ph.D. in electrical engineering. They still don't know how I did it, but I knew exactly what I wanted--I went charging like mad. After a year, as I knew I would, I met someone from NASA and they said "My God, with your background"--see I had worked on digital flight control systems for the Titan and so forth. I got a job, knew exactly what I wanted, and the timing was such that we changed the fundamental flight control designs on the lunar module, the command service module--all of those modules that went to the moon. And there I was, a young engineer, around 30 years old, and I was responsible for the primary control systems for all the spacecraft on the lunar mission--every single one. What a neat deal! And we never had a problem on any of that. I mean the design was just right. It was just a great experience.....

Now, let me tell you another story--you'll love this. On Apollo 13, the one in the movie, where an explosion occurred on board and we had to unexpectedly circle around the moon and come back, and we weren't sure we were gonna get back...The way you would normally do this mission, the lunar module would never fire its big engine with the command service module attached--what you normally do is both of 'em go over to the moon, you insert, and then you separate. And the lunar module goes down and comes back. Well, earlier in the design phase, we had a big discussion in my area of flight control, and that is, should we ever design for a contingency that says you don't insert in a lunar orbit, you just fly back around but you still have to fire this big engine on the lunar module with the entire command module on it? It was a *contingency* thing. I wanted to make sure that we developed a control system for that contingency.

So I worked with the MIT Instrumentation Lab [now Draper Labs], and we developed a software that would do this basic design, and I took it up to the NASA software control board, which was being headed by Chris Craft, and Chris--now this is a beautiful thing--Chris, in open meeting, turned it down, said we cannot afford the schedule slip, and so on, and I was crestfallen. So as I'm walking out the door, Chris says, "Shhh, come on over," and he puts his arm around me, and he says, "I don't care what I said, get that mother in as soon as you can." I said "Yes sir!" So I

went off and we worked the hell out of it, and four months later we came up to the software control board, and I presented the modifications for approval, and it's an impact to take it out, at that point--it would have cost more than keeping it in. (*Laughs.*) OK. That design, when Apollo 13 flew, that was one of the reasons we got it back. Without that capability we couldn't have done it. [*laughter and general excitement from the table*]

DENNIS WOOD: All those days I sat on tenterhooks watching the TV. I'll never forget that as long as I live.

COX: So that's an example--you gotta have people who reach beyond what your work is today. You constantly have to stretch it.

DENNIS WOOD: Did the guys in there realize?

COX: I'm not sure they did. But from our own area, people knew.

DAVIS-FLOYD: So what happened to NASA after that? All that wonderful energy obviously dissipated.

COX: What happened, basically, was the relationship between engineering and ops and program management changed after we went to the shuttle. See previously, you had these programs where you build 'em, fly 'em, and throw 'em away and start over every six years. And everything re-initializes, and the relationships between the various things that it takes to do the job have some stability in a cultural, organizational sense. When you look at the shuttle--opening the program for 30 years, 40 years, 50 years--the engineers did their thing, the operators began to take over, and then guess what? When you make delta changes or whatever, the operators say, "We don't need engineers as much any more, we've been operating this stuff--we're gonna do most of the engineering." And so there's a shift of balance, control, power, energy.

And operations and program management have become more powerful, and the organization has become skewed with regard to balance between the various elements. And engineering has ended up, over a long time, sort of being secondary--"I'm only calling you in when I have a deep problem. Otherwise, we're going to do it ourselves." Well that's a second-class citizenship relationship--not good. *Not good.* So some of the problem within NASA from an engineering standpoint is that engineering itself has sort of been downgraded without viable new work opportunities, and that what really counts is the operators getting in front of TV with a launch--they get the credit, the crew gets the credit, and the real technical people--"Well, we'll call 'em when we want 'em, but we really don't need 'em that much any more." So it's really changed the culture.

DAVIS-FLOYD: Was that part of the problem on the Challenger?

COX: Yes.

DAVIS-FLOYD: You know, I should tell you something. At an academic symposium last May at Rice, I tried to sum up what SATWG's about--the central issues and all the stuff that goes on at the meetings....there were several things about SATWG that intrigued the academics at the meeting, like the dualistic tensions between government and industry, between competition and cooperation, old and new paradigms. But the other thing that intrigued them so much was you personally. They thought you a fascinating blend of New Age and technical, visionary and practical, so this chapter may end up being as much about you as anything. It may be about you and SATWG together, or it may just be about you--you were very intriguing and very compelling to them as a character to read about, as a hero in the story.

Staying in the Game

A few weeks after the above interview, which took place in early October, 1995, I attended the second SATWG conference to be held in Washington D.C. By this time, two years after the first D.C. conference, both the discourse and the action had shifted toward partnerships and consortia. The main issue was still the need for reusable launch vehicles (RLVs). The hot topic was the fact that NASA had given preliminary sanction to a multi-million dollar program to build an experimental RLV, called X33, and three big teams had been formed to bid on this experimental project: Lockheed and Martin had actually merged as a company, and Rockwell and NorthrupGrumman had teamed, as had McDonnell Douglas and Boeing. At the first D.C. meeting I had asked Gary Lee, the Boeing rep, why Boeing didn't partner with some other company--like McDonnell Douglas--to build an RLV; he had answered that "consortia don't work." Now, two years later, I asked him why these two had decided to team up after all:

GARY LEE: [I can't comment on the specifics of why those two in particular], but I can give you some generic reasons why any two companies might want to team. One is reduced risk. Reducing risk by sharing the risk, essentially. The overall risk doesn't go down, but you're sharing it. And financial investment. If you team, you don't have to put up as much money, because you're sharing the investment. So your total financial risk goes down. You also team for complementary resources--resources one company may not have, would be existing in another company. Competitive posturing against other competitors. And, also, to make available sufficient and adequate investment,

you team as investment partners, each putting up so much money. That's a little different than just lessening the risk. Any one or all of those could apply to any teaming arrangement.

Each major player in the X33 game has their own design--the McDonnell Douglas and Boeing RLV (a variant of McDonnell Douglas' earlier Delta Clipper) would take off vertically and land vertically; the Rockwell/Northrup Grumman model would take off vertically and land horizontally, like an airplane; and LockheedMartin is working on a different version of vertical takeoff--horizontal landing. These three designs will compete to become the X33 prototype whose development NASA will fund partially fund. (The winning team will front the remainder.) The idea is that once the experimental design has been tested and proven, Wall Street investors will have the confidence they need to fund the development of an actual RLV:

ENGINEER: NASA has determined a certain funding limit of what they wanted to invest in the next launch vehicle. It's going to be somewhere in between half and a billion dollars [probably 800 or 900 million]. And, that's a significant amount of money. The industry itself wouldn't necessarily be able to afford to take that risk. So, you accept the program on its guidelines and on its time frame, in order to at least get that amount of money to move the technology at least that far.

DAVIS-FLOYD: So that you can stay in the game?

ENGINEER: So we can, yeah, stay in the game. Because right now it's the only game in town....Other than.... either investing yourself, which means you'd have to put up the billion dollars, or go off to venture capital money--banking money. But, the risk is too high for both of those things to happen yet. And so, that's why the government needs to fund that early risk, so you then can convince the industry, or venture capitalists, to put in their own money.

DAVIS-FLOYD: So, once the X series is built, and it looks like it's a good idea, then is the government going to fund the next stage, and build the real thing? Or are they going to leave that up to industry?

ENGINEER: Well, the impression I'm under is that they'll turn it over to industry, which still wouldn't fund it themselves, they would go to Wall Street or venture or bankers. But now you'd have a business plan. And now you've proven whatever the technology risks are that you're probably at a stage where you can seriously talk to venture capital or you can seriously look at some sort of multi-company venture, whatever. No single company still would put that much into it themselves. It still would take probably too long to recoup your investment. But, you've

taken the risk out and you've demonstrated most of your technologies and you've also created this business plan, which could then, itself, be taken forward.

These issues dominated a dinner conversation I engaged in with Ken Cox and Henry Brandhorst. Henry at that time was in charge of NASA's Power Technology Division at NASA/Lewis; he and his team were responsible for tracking and evaluating major space-oriented technological developments in power generation, storage, and distribution nationally and internationally. Five years earlier, it was Ken and Henry who jointly conceived the idea for SATWG; thus this dinner seemed an especially fitting finale to my last SATWG conference. Over seafood and wine, they taught me the Dance of Permanent Whitewater Management⁵:

HENRY BRANDHORST: We have had this culture which says you gotta do everything with paperwork--you gotta have dual, triple and quadruple redundancy on things that would have never failed anyway...My last project came in underschedule and underbudget. In that contract, there were zero change orders. The contractors start building the thing, and then they want to come in and say, "You want to change it, right?." And I said, "No. There are no change orders. Your objective is to deliver this hardware in two years...And we're not going to talk about change orders. That's paperwork." And they had to change their internal business systems--there were great stresses in these companies. But we ended up with a much more efficient process, with a team that truly worked and did it and did the paper that they had to do. But not these other kinds of paper that you don't need to do.

DAVIS-FLOYD: And so you're saying that if you used that streamlined kind of process to build an RLV, that you could do it for 2 billion instead of 15 billion dollars?

BRANDHORST: Yeah. Probably could.

COX: Close. See, it's like building a house. The guy starts to build it, and half way up, you're saying, "I don't like the windows there," or, "Let's tear up the foundation because I want to move the plumbing." Now do you think that's gonna cost you some money?

DAVIS-FLOYD: Of course.

COX: Well, that's what the government does, all too frequently.

DAVIS-FLOYD: They change it.

COX: They change it. And, the contractor depends upon the changes when he makes the bid in the first place. Because there's a huge profit every time you change....The companies live on the government agreeing to changes, not on the original contract.

DAVIS-FLOYD: Wow. Well, I was excited when I first heard that NASA was going to build an X33--it sounded good until I learned that X means "experimental." They're building an experiment, rather than the actual thing. Gary Lee and Ray Garbos were telling me earlier today that the most efficient thing to do would be to build a real, not an experimental, SSTO.

BRANDHORST: Right.

DAVIS-FLOYD: And put all the money into that. But, instead, the money's going into the designs for subscale prototypes for the SSTO...which won't actually penetrate the atmosphere. And it'll take 3-4 years to design and build the prototype. And, then, based on that, then maybe you do, maybe you don't go for the next stage..In the meantime, Motorola and Teledesic will be launching their big communication satellite networks, and that initial business will be lost.

BRANDHORST: Right.

DAVIS-FLOYD: Why does it have to be that way?

BRANDHORST: It doesn't. The point is that if an industry were to decide, "I see a market out there, that I can capture, and I believe in our designs," then they should build.

COX: And, that's exactly what France and Japan and others are going to do, when they don't start with all this past history.

BRANDHORST: When you see a void in the market, you can decide to fill it. And you do it on the guess of whether you're going to make a profit on that. And sometimes you're right. And sometimes you're wrong. Boeing bet their company on the 747. It wasn't the government that came in and said "We need an airliner that will carry 500 people to Europe."

COX: It was a tough decision.

BRANDHORST: Yes, it was. And, they recognized that they bet the company on it. But, that's what business is about.

COX: Instead of talking about entrepreneurs as risk-takers, why don't we think about them as risk "managers"? A risk-taker says, "Oh, you're willing to take risks." What you want to do is manage, responsibly manage risk.

BRANDHORST: I agree. And, when you hear the companies talk, they're all caught up in this old way of doing business, all this paperwork. No rocket has ever been built that will lift the paperwork that it took to create it.

(Laughter) OK? And, we don't need that. We need enough of that--you need the right kind of paperwork. But, you don't need what we've got. You don't need the thousands of engineers working on, each working on a little piece. You need an integrated activity with fewer people.

DAVIS-FLOYD: It seems so simple and clear when you two sit here and say this is what is needed. And yet, in the taxi today, Gary and Ray were saying, "Well, we're going to lose Motorola's Iridium business and part of the Teledisc launches--those will go to the Japanese and the French and the Russians." Lockheed has a stake in the Russian commercial launch program, so they won't totally lose. But I want to know--why are we building an X instead of the real thing?

COX: Well, let me go back now. Remember that roundtable I went to in Washington a year ago? During that meeting, the head of Lockheed, Dan Tellep, got up and said, "X series is unnecessary. Lockheed is prepared to put on the table the full-up vehicle and go full-bore." And Dan Goldin, NASA administrator, said, "We are planning an X vehicle series with joint government-industry financing."

DAVIS-FLOYD: Oh no. Why?

COX: Partly because it fills a lot of NASA jobs.

DAVIS-FLOYD: So he consciously, knowing, I mean, he had advice from industry that this was a marginal endeavor and he chose to do it anyway?

COX: Well, the truth is that industry was split on this issue, so he did get conflicting advice.

DAVIS-FLOYD: And, the congress is agreeing with him? I mean why.....

COX: Well, you heard the chief congressman speak today. His district benefits by going to X vehicle. The political process is very complicated.

DAVIS-FLOYD: I see. So--short-term gain in jobs, and we lose in the long-term launch market.

COX: It's a complicated system.

BRANDHORST: That's why I talked earlier about changing the culture.

DAVIS-FLOYD: How do you guys keep your spirits up? I mean, you can see the problems that could have been avoided and you have to just sort of work with that....

BRANDHORST: Some days are better than others. Some days are diamonds. Some days are stones. (*Laughter*) I mean, you can grind away on us, but any system created by humans can be subverted by humans.

DAVIS-FLOYD: I mean, it is phenomenal how administrators can make decisions that affect thousands of people.

BRANDHORST: Yep. You see, what the people get worried about....do we dare bet the company? The answer is "Why not?" Isn't that what entrepreneurs do all the time?

DAVIS-FLOYD: Well, evidently, the president of Lockheed was willing to, more or less, bet the company...

COX: He was. He said so. I was right there.

BRANDHORST: Now Lockheed could have chosen to no-bid this current activity.

COX: Well, be careful....I had a conversation after the end of SATWG today. The conversation was simple. There are three prime bidders. Conversation was...what happens if all three refuse to bid on the NASA contract?

BRANDHORST: Right.

DAVIS-FLOYD: Whoa. That would be powerful.

COX: Yes.

DAVIS-FLOYD: That would be a real statement..."We're not going to play this game."

COX: This was the discussion.

DAVIS-FLOYD: So instead of bidding the NASA contract, why don't the three teams just get together and build the rocket?

BRANDHORST: That's one option. But the other option is that any one of them can go it alone. If they have the courage of their convictions.

DAVIS-FLOYD: So, it would be a lot easier for one company to make the decision to do it alone if all three companies agreed not to bid the contract. Because, otherwise, it will be two of them, or one of them at least, getting all this federal money, while the other one is taking all the risk.

BRANDHORST: That's right. So, even if Lockheed says, "Yeah, we could build this on our own," and they are willing to, you have to say, wait. If there's still a federal government contract out there and Boeing gets it, then we can't compete because it's not costing Boeing as much money to develop their model--they're going to get subsidized by

the government. So Lockheed would be weakening itself, and they would have to make a decision whether to do that. Unless they all get together and decide to no-bid.

DAVIS-FLOYD: Is it really possible that they might decide to no-bid?

COX: Uh...I'd have to give you a Las Vegas bet answer. I wouldn't give you fifty-fifty that they wouldn't, but I will give you fifty-fifty they would each and every one consider it.

BRANDHORST: Yeah. There's enough dissatisfaction. Every one of the three is going to be thinking seriously about it.

DAVIS-FLOYD: How are these three team arrangements working?

COX: I have heard that the Boeing-McDonnell Douglas merger, in order to bid on this, is having difficulties. In some cases, the cultures have not adjusted very well between the two companies...

DAVIS-FLOYD: I see. McDonnell Douglas already had a big investment in the Delta Clipper, right? Was that the problem?

COX: Well, it was actually more than that. There were three cultures. There was a McDonnell Douglas out at Huntington Beach that had the Delta Clipper. There was McDonnell Douglas at St. Louis which is a totally different culture that had another design which was not the Delta Clipper. And, then there was Boeing who had a third design which was not either of the two. They mushed them together. And, instead of playing a win-win game, they made an arbitrary "you will go this way"--which may have generated some unhappiness among two out of the three.

BRANDHORST: It may not have been arbitrary, but, I mean it was--

COX: --in essence--

BRANDHORST: --an inappropriate decision.

DAVIS-FLOYD: But--there's a whole book about how Boeing changed their culture, developed all these management skills, refined the teaming approach...

COX: They have done all those things--within Boeing. Tribal community Number One may do all this learning, but when they interact with tribal community Number Two, they may not reconcile anything.

BRANDHORST: And they may not share. And they may not understand.

DAVIS-FLOYD: Is it that the engineers refuse to get along with each other? Or is it that the management didn't allow the context within which the engineers could...

BRANDHORST: No. First of all, the management didn't allow the context.

COX: Right.

BRANDHORST: But, secondly, the engineers would have had a great deal of difficulty in dealing with it and building the trust up between the groups. In our community, particularly, trust is very important. [But it's hard to build trust among the workers when you start with top-down management decisions that don't work.] Far too often, we snatch defeat from the jaws of victory--by management decisions. There were some challenges there that were not insurmountable....But they chose not to surmount them.

COX: And look, Robbie, this explains some of my dance characteristics.

DAVIS-FLOYD: Your Dance of Whitewater Management?

COX: Mm-hmm. When I do the dance, and I get too near the edge, sometimes I have to back off. Because it's better to back off than to get picked off and you're no longer a player.

BRANDHORST: That's right.

DAVIS-FLOYD: I see. So, you have to stay in the game?

COX: I have to stay in the game! You don't have to stay in the box, but you do have to stay in the game.

DAVIS-FLOYD: And you can change the game while you're in it. But, if you get too far out of it, then you lose.

COX AND BRANDHORST: Right!

DAVIS-FLOYD: So it is a dance.

COX: It's a hell of a dance!

BRANDHORST: It's a hell of a dance. You're steering a raft down this real risky river. How far out can you go? And, then, you go over the waterfall, it's over with.

COX: And you may have two outcasts right at this table with you. On the edge. Or maybe over it?

(Laughter)

BRANDHORST: Yeah, that's what the deal is.

COX: That IS what the deal is. God, I think it's wonderful to have such a dynamic dance, myself! *(laughing)* Even though it would be a hell of a lot easier to retire and go vegetate somewhere and watch television.⁶

1. The financial crisis in the Far East that has occurred in 1998 has forced Japan to cancel virtually all earth orbit and lunar base commercial activities such as tourism plans including theme parks and space hotels.
2. In keeping with his consistent efforts to mediate the government/industry, competition/cooperation dichotomies that generate the dynamic of the contemporary aerospace story, Ken conceived SATWG as a networking and information-sharing enterprise. The spirit of the meetings encompasses cooperative and mutually supportive relationships between NASA and industry, and among corporations as well. Nevertheless, this harmonious ideal often comes into conflict with various companies' insistence, at times, on the high-level secrecy of certain of their projects. When such conflicts arise, the engineer making the presentation will pause and state apologetically, with head downturned, that his company requires secrecy and so he can say no more about this particular issue. Everyone nods understandingly and the presentation goes on with the non-classified material:

Question from COX: Can you tell us if you are going to form partners with other industries, or consortia, or any plans with regards to technology demonstrations, etc.?

Speaker: Not really, not at this time--I wish I could share more with you--but uh...[*some one in background loudly says "Could you repeat the question?" generating general laughter*] The question I *can* answer is that our strategy is to basically either form partnerships or get funding for this vehicle.

When the information cannot be shared, as we have just seen, an effort is made to make that refusal as polite as possible. I discovered, when I probed into areas that were too secret to discuss, that one strategy for accomplishing that often employed by the business managers at SATWG is to attempt to make the refusal invisible, and I learned a lot about the art of doublespeak:

DAVIS-FLOYD: So what exactly is your role in this possible joint venture with the Russians?

GARY LEE: The details are what we are keeping very proprietary at this point.

DAVIS-FLOYD: But what's *your* role in the process?

LEE: Personal role?

DAVIS-FLOYD: Yes.

LEE: Just as a technologist right now. We have a separate organization coming out of research and a central engineering function.....I have people assigned now full time to pull together the study.

DAVIS-FLOYD: You have people assigned? Are you in charge of this process?

LEE: The Boeing company is a matrix organization...

3. In Disembodying Women (Harvard U. Press, 1993), Barbara Duden analyzes this image as a dead abstraction of "life." But for the SATWG attendees "the blue planet" profoundly connotes the astronauts' visual and visceral experience of one world consciousness--an experience in which they can share through this image; for them, the image of the blue planet with its swirling atmosphere is one of surpassing beauty and transcendence--a visual culmination of "the vision thing," and a powerful testimony to the worth of the space enterprise in which they are so personally engaged.

4. Flight technology demonstration programs are being built today, and both the X-34 and the X-33 may provide valuable information for future space movement activities. However, by 1998 it has become clear that the SSTO is not going to represent the wave of the immediate future. Rather, the present trend is to explore two-stage-to-orbit launch capabilities by upgrading the present Shuttle, or by building a second generation Shuttle. The key drivers that have taken the single-stage-to-orbit launch vehicle out of competition are the concern over operational costs, and the need for some agreed upon combination of commercial and government cost sharing. Virtually all of the commercial space activities in earth orbit will depend upon Expendable Launch Vehicles in the next decade.

5. Here is how Ken describes the "Dance Of Permanent White Water Management":

We are living in a time of the most rapid change in the history of human development and evolution where the challenge is to provide both individual and collective leadership in the midst of this turbulent environment.

Organizations and institutions must adapt to increasing levels of complexity to remain viable and to properly evolve.

We must take individual responsibility and avoid searching for someone higher in calm water who, we hope, knows the big picture. We should support lifelong learning and encourage individual discipline, integrity, risk taking, and leadership practices. In the area of teaming, we must develop creative partnering skills, and utilize dialogue, shared imagination, and active listening in order to align intentions, visions, and goals. We should encourage individuals to create meaning in the work environment, and collectively value diversity, creativity, and intuition.

6. Far from retiring to watch TV, Ken continues on in the Dance. Since this article was written, he has gotten NASA, Rice University, and various high-tech companies to pool their resources to put on two conferences in Houston on nano-technologies. The second of these, the International Nanospace Conference of 1998, involved eleven countries and focused on blending nano-technologies and bio-technologies for application for human exploration and settlement of the solar system.

His most recent NASA assignment is to serve as the Chief Technologist for Human Exploration and Development for Space, coordinating all the technologies for NASA's various space projects.

He has provided me with an update on recent SATWG activities:

In June 1996 SATWG was hosted by the Air Force Space Command. The meeting theme was "Cooperative Space Strategies." In October 1996 the host was Lockheed, and the meetings focused on "Earth Orbit Operations and development as an enabler for Exploration. Auburn University was the host for the April 1997 meetings, and the theme was "Facilitating and Nurturing Human Exploration and Development of Space." Boeing hosted in October 1997, appropriately on the theme "Space Plane." April 1998 saw SATWG hosted by the Shuttle Upgrade Program Office and centering on a discussion of "Cross-Cutting Partnerships and Shuttle Upgrade Technologies." The host for the latest meetings, in October 1998, was USA and Shuttle Upgrade Program Office on "Space Launch Operations for the Future."

The original Strategic Avionics Technology Working Group (SATWG) was renamed the Aerospace Technology Working Group (ATWG) before the October 1998 meeting in Florida. The ATWG charter identified four focus technology areas as 1) Electronics, 2) Software, 3) Systems Engineering, and 4) Operations Engineering. These represent a strong shift away from policy discussions and a re-orientation toward technology sharing and development. Recent products of ATWG discussions have included:

- Assessing standards and avionics design guides
- Reviewing cross cutting technologies
- Evaluating new ways of doing business, and cooperative sharing concepts
- Recommending potential upgrades for existing NASA systems
- Proposing improvements for NASA/Industry systems

According to Ken, emphasis in the future will focus on "integrating avionics technology with operations concepts development, engineering design, and ground/flight test demonstrations," as well as on ensuring that ATWG concepts and suggestions get acted upon by NASA and the aerospace industry.

List of Acronyms:

AIAA--American Institute of Aeronautics and Astronautics

JSC-- Johnson Space Center, Houston, Texas

LEO-- low earth orbit

RLV-- reusable launch vehicle

NASA-- National Aeronautics and Space Administration

SAIC--Science Applications International Corporation

SATWG-- Strategic Avionics Technology Working Group

SSTO-- single stage to orbit

**COMMERCIALIZING OUTER SPACE:
THE SATWG STORIES**

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