INTERVIEW WITH

Charles Kennel

BY DON COHEN

Dr. Charles Kennel was associate administrator for the Office of the Mission to Planet Earth from 1994 to 1996, when he helped restructure NASA's Earth Observing System. For many years he was a professor of physics at UCLA, carrying out research in space plasma physics and astrophysics. He is formerly the director of and now professor at the Scripps Institution of Oceanography, and he was the founding director of the Environment and Sustainability Initiative at the University of California, San Diego. Don Cohen spoke to him at the Jet Propulsion Laboratory in Pasadena, California.

COHEN: How did you come to work on the Earth Observing System?

KENNEL: I had spent my career since coming to UCLA working in astrophysics and space science. I'd been on a lot of NASA committees and NRC [National Research Council] committees and was deeply interested in NASA as an institution but had no idea of taking a management role. I recall I had been on one NASA panel that advocated a program of small spacecraft with very targeted missions in space science. I felt that small spacecraft were a good way to go for that subject; they offered a lot of flexibility. This idea turned out to be important for my subsequent life at NASA.

One day I was sitting in my office at UCLA and got a phone call from Dan Goldin [then-NASA Administrator]. He said, "Charlie, I'd like you to come to Washington."

I said, "You mean to work in astrophysics and space science?"

He said, "No, no, no: Earth science."

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When I asked him why, he said, "It's a long story, but I'd like you to come and talk to me about it."

So I duly flew to Washington. We had an eight-hour discussion. The gist of it was that the Earth Observing System needed to be restructured. We couldn't sustain large spacecraft financially and needed to go to a system of small spacecraft. Goldin thought a lot of people in Congress and the political sphere believed that NASA, NASA scientists, and the universities working on such things as the ozone hole, deforestation, and climate change were being unduly alarmist in order to feather their own research nests. He said, "You're a reputable scientist from another field. You're going to have to make tough decisions, but I'm going to give you a completely free hand. I want you to make them strictly on the basis of science. Congress will perceive you as an independent voice." He helped me very much by giving me two wonderful deputies, Bill Townsend and Mike Mann. They were able to run the institutional and the engineering side of Mission to Planet Earth, and did so very well.

COHEN: What were some of the challenges of restructuring the system?

KENNEL: We needed to go from two large spacecraft to many small ones. The challenge was to integrate the operations and data from a complex system of satellites to get the multidisciplinary knowledge that was needed. For that, we had to work with the scientific community. The essential point was that NASA engineers and the scientific community worked together to restructure the program using system concepts to build an Earth-observing *system*.

The original idea had been to observe all the variables pertinent to the earth system simultaneously. That's how we first ended up with more than twenty instruments on each of two giant spacecraft. The integration of twenty instruments with demanding and conflicting requirements is difficult and expensive. We needed a little bit of give on both sides—the scientists had to figure out how to interrelate data taken at different times and places, and the engineers had to figure out how to make the measurements NASA had promised on a collection of smaller spacecraft. Clearly, absolutely simultaneous measurements were best. The system of satellites ultimately was able to observe all parts of the earth system during the same time period, but not simultaneously. By making these compromises, scientists and engineers working together figured out how to get scientifically meaningful results at one-third the original cost.

NASA then went to Congress and said, in effect, "Look, we're really in the business of making twenty-four measurements, not necessarily building a giant spacecraft." Congress gave us the leeway to put the instruments on new spacecraft without requiring a separate Congressional discussion of each one, so long as we brought the system in on a budget that enabled some cost savings.

COHEN: So you had quite a bit of freedom to decide how to build the system.

KENNEL: There were other kinds of freedom. We knew we were going to need measurements of ocean color. When you measure ocean color from space, you basically measure the amount of chlorophyll, which measures the richness of the ecosystems in the upper 100 meters of the ocean. These marine ecosystems are responsible for retiring about half the carbon dioxide in the earth system, so you need ocean color measurements. There had been an experiment in 1977 called the Coastal Zone Color Scanner, which did the first measurements. Then there was a long hiatus. When the Earth Observing System [EOS] came along in the mid-nineties, we consulted with our international colleagues in the committee on Earth-observing satellites and found that three or four nations were planning color missions. We, NASA, decided that we could cancel our small ocean color mission, EOS Color, which would have cost between $100 million and $200 million. But we didn't leave the U.S. ocean color community completely bereft. We created a program called SIMBIOS [Sensor Intercomparison and Merger for Biological and Interdisciplinary Ocean Studies], in which NASA actually paid for oceanographic ships to do validation experiments for the other international satellites. As a result, we got their color data and they got their data validated. So long as somebody was making the measurements, what was needed was intercalibration, so the different spacecraft data could actually talk to one another. That idea came from looking at satellites as a part of an observing system that could include other platforms.

COHEN: Did you have a complete concept of the system at the beginning or did it develop as you went along?

KENNEL: We had the general idea of a system of satellites. Each smaller spacecraft could be adapted to the instruments it was carrying with fewer requirements conflicts. The system would be more robust, because if you lost a small spacecraft, you would still have the rest of the observing system, whereas if one of those big shuttle experiments failed, you lost twenty measurements and five years. Because it was a system, an iterative process of incremental redesigns came out of the dialogue between the science community and the NASA engineers.

COHEN: What was that process like?

KENNEL: Nobody likes to lose funding, but we did have to make cuts. When you look at the different parts of a complex system, it's tempting for a manager to say, "We can save money on this subsystem. I need the money someplace else." That kind of struggle goes on all the time. The questions in my mind always were, "When are we going too far, how will I know we're going too far? Will the loyal engineers who are trying to make this whole system go tell you if things are getting out of hand and you've gone too far?"

There's always a trade-off. You have to sense where the sweet spot is. If you're running a big organization, you don't know. The engineers know their jobs very well, but how do I know when they are taking on needless risk because I asked them to?

COHEN: Did they tell you?

KENNEL: I hope they did eventually.

COHEN: What did you do to get them to talk to you candidly?

KENNEL: Remember, I had an absolutely wonderful deputy, Bill Townsend. He had the job of telling me, and everyone else, engineering truth. Bill would very often go out to Goddard Space Flight

Center to tell them, "I've got one more redesign study for you." They would groan, not always inwardly. But I think by going and asking them regularly, "Can we look at this option, can we look at that option?" Bill began to find out where the really tender spots were in the system, where help was needed. Goddard and Headquarters had an ongoing dialogue for all my three years.

COHEN: He talked face to face with them?

KENNEL: He was out there twice or three times a week. They began to trust him. His continuous pestering for new trade studies, new re-thinks, in its way led to defining what NASA really wanted. We weren't yet building the spacecraft, so what we were doing was getting the initial design right. We benefited from three years of dialogue between scientists and engineers about the initial concepts and designs. Other parts of the Agency had trouble with the faster, better, cheaper concept, but we were trying to implement it because it was right for Earth science—at least to go to smaller spacecraft. I think we were going for better and cheaper, but not faster. We built up a relationship of trust with Goldin, so there were not the bad feelings in that program that there were in some of the others.

When I left NASA in '96, the concept and the budget level were basically set. Once that was done, NASA could concentrate on executing. It fell to my successor, Ghassem Asrar, to make sure that the individual projects got managed rigorously. NASA managed all of those launches without a failure.

COHEN: Several NASA project managers have talked to me about the value of a longer-than-usual planning and design phase.

KENNEL: I think the benefits are huge. The biggest mistakes are made early on. One of the things we're doing in the [National Academy of Sciences] Space Studies Board is trying to get more realism into the initial mission conception. Our decadal surveys of astrophysics, planetary science, and heliospheric systems all will have study teams of scientists *and* engineers *and* project managers and will all do independent cost analysis. So in the future, when the Academy makes a recommendation, our panels will have thought through some of the major trade-offs.

COHEN: So what, briefly, is the chief benefit of having this system of satellites?

KENNEL: The key thing about spacecraft is that they observe the earth evenhandedly. The same instrument with the same calibration observes all parts of the earth in the same way. The purpose of the next round of Earth observing is not to diagnose whether climate change is happening or even really to improve the forecast of global climate change, though it will do both. Then, what is new? Every region will soon be deploying its own ground system to measure the things they care about. They'll correlate their own data with satellite data that will provide the global framework for their regional measurements. Suppose you live in Southeast Asia and read of problems in Africa; because of the impact of climate change, species are moving northward or moving up the mountains seeking colder weather. That's all very interesting, but it doesn't tell you what's happening in your region, or how it interacts it with other things you care about. The real issue is how will climate change affect my region, my economy, and the things I care about.

COHEN: Is part of addressing those concerns finding the right language to describe what's happening?

KENNEL: One of the great things the Intergovernmental Panel on Climate Change [IPCC] did was teach us in the scientific community how to speak more effectively to decision makers. Their last report reviewed the state of scientific knowledge on all the important climate questions they could think of and came up with an objective review. When they express these results in scientific terms, scientists in every country can check them out. The other part of the IPCC report recognizes that most decision makers don't understand the science and have a different set of questions. So the panel included a second layer, which they call the summary for policymakers. The leaders of the teams that did the scientific assessment sat down with the policymakers, listened to their questions, and tried to answer them in terms that the policymakers can understand. The IPCC invented a carefully thought-out language to convey the degree of their certainty about how the science bears on the main policy issues.

COHEN: Giving a kind of scientific precision to non-scientific language?

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KENNEL: Politicians meet all sorts of people, including people from either extreme of the spread of scientific opinion and understanding. They need a way to calibrate whether the person they're talking to is a crackpot or speaking from the center of the scientific community. Having an assessment that's been worked on by literally hundreds of scientists and revised many times in collaboration with policymakers gives the policymaker a way of calibrating the statements of the individual with whom he or she is speaking. The precision of that language is very important. This language also helps tremendously in public communication of the IPCC.

COHEN: In the past, certainly, there's been a lot of controversy about climate change.

KENNEL: One of the greatest difficulties that we've had in the climate debate came from a clash of fundamental values between the scientific community and the media. The media live in a world in which everything is politicized. When 52 percent of the people are on one side of an issue and 48 percent on the other, that's a big majority. So it is good journalistic practice to have statements from both sides of an issue.

But with climate change, hundreds of scientists are represented by the IPCC, which crafts collective statements. The IPCC is careful to characterize the degree of uncertainty of each statement it makes, but uncertainty is always a part of any scientific conclusion. The media, following their most basic ethical principles, seek out advocates of opposing views precisely because their view is opposed. The opposing views are given equal weight in the public presentation, whereas they do not have anything like equal weight in the community that's doing the research. The net result is the general public thinks significant uncertainty exists where it doesn't. Because of the checks and balances of the scientific method, because scientists meet frequently and check each other out, and because they have things like the intergovernmental panel, there does tend to be a broad consensus about at least the main aspects of the field. ●