

**American Meteorological Society
University Corporation for Atmospheric Research**

TAPE RECORDED INTERVIEW PROJECT

**Interview of Walter Orr Roberts
November 16, 1987**

Interviewer: Ed Wolf

Nancy Gauss: -- was a good idea to start out that way.

Walter Orr Roberts: Well, why don't you do that?

Nancy Gauss: OK. This is Nancy Gauss (sp?), and Ed Wolf (sp?) is going to be interviewing Walter Orr Roberts at NCAR. The date is November 16, 1987.

Ed Wolf: Well, Walter, the cold that you picked up on [Pakistan and?] Berlin is going to be recorded for posterity [the other?] day.

Walter Orr Roberts: (laughs) Sorry about that.

Ed Wolf: Last time we talked a lot about the origins of NCAR, and the purpose of this interview is to pick up from there and try to come up more toward the present. One question we might start off with is to talk about some of the people who were influential in a positive sense on the development and the success of NCAR who were not NCAR staff people but who were visitors or trustees or otherwise connected with NCAR. It'd be interesting to have in this historical interview a slight discussion of some of these folks.

Walter Orr Roberts: That's a fascinating question. I'm just trying to think as I go at it. I think from the outside, one of the people most influential was Randy Robertson from NSF. He was one of the people who really had a vision of what NCAR

might be. And sitting here on the mesa before there were any buildings or anything, I remember spending a good part of an afternoon with Randy, sitting over about where the Fleischmann Building is now, looking down to the north, and sort of drumming up the three goals that we set for NCAR: to first and foremost be a place where good science was done with resident scientists and visitors; and second, to be a place where major planning efforts were made to figure out how to attack the really big problems that atmospheric sciences cooperatively with universities, with government agencies, with the staff of NCAR, and so forth -- this is before we added staff; and thirdly, to provide the facilities necessary that were too large and too complex or would be dislocating for a single university by itself to create. And I remember particularly that we developed out of that meeting and always subsequently said that NCAR is first and foremost to be an intellectual center rather than a facility or a building or anything like that. I remember also that at that time, I had some strange views about the best kind of physical facility to be in. I thought that a building that had been built for something else and was remodeled was the ideal (laughs) facility. Maybe I was thinking back to [TP8?] and some of those things that remodeled in those days. But I would say Randy was one.

And Alan Waterman, also, who was director of NSF, played a big role. He had been very influential when he was head of the Office of Naval Research in setting up the right kind of intellectual sort of rules of the game for support by a government organization -- the Navy at that time -- of science. And the Office of Naval Research was regarded as an ideal model of how the government should

support research, leaving freedom to the scientists to plan, to do, to do the things that they thought most important, yet at the same time, constantly keeping the focus on the overall national needs.

Another person who played a big role, from NSF again, was Paul Klopsteg, who served on the original academy committee, and I guess one has to say also Lloyd Bernker, who was chairman of the committee after John Menoyman (sp?) died -- after John Menoyman got sick. But there were many, many people on the outside who had a huge intellectual impact on the place. Scientifically, I guess the person most influential was Phil Thompson, from the inside. Phil had come from the improbable place of Telus (sp?) -- was it Air Force or Army? I can't remember.

Ed Wolf: Air Force.

Walter Orr Roberts: Air Force, yeah. And came over while he was still on duty from Sweden to help in initial planning. And I know that the main task that we set for ourselves -- Phil and I, when Phil was the associate director -- the main task was to make it attractive for the really top flight, right people to come and work at NCAR. So first and foremost, the people who had vision about where the atmospheric sciences should go, and the facilities and all of that, the building and everything else, sort of was secondary.

Let's see -- other people that played a major role in shaping it... There were lots of them. Earl Dresser (sp?) is one who kept telling me that my ambitions were too modest -- the size and budget and everything else. I remember figuring that ultimately the budget might get up to \$6 million but that

would be awfully big. (laughs) And of course Tom Malone played an important role through the years.

Ed Wolf: How about some of the early or even later visitors who interacted with us, like Jule Chimey (sp?) and Ed Lorenz?

Walter Orr Roberts: Yeah, Ed Lorenz is probably the one that comes primarily to mind. He was a person of enormous imagination and enthusiasm, and he had been coming for some years before that in the summer to the high altitude observatory. And of course he was one of the great leaders in turbulence theory and in the broad problems of the general circulation of the atmosphere, and I guess as much as anybody, Ed was a constant friendly critic and a person full of imagination about the important scientific problems to tackle. And, of course, his lectures were incredibly lucid on the most difficult subjects, and so he had a very big intellectual impact. Turning to -- I think Ed, though, was the one who had the biggest impact from the scientific standpoint. Interesting to talk to Phil about it, because Phil was very much an intellectual leader and helped bring the right people. A person that had a lot of impact, too, before he came, was Pat Squires, and then, of course, he joined the staff early on.

Ed Wolf: Well, perhaps we ought to move on to some other questions, and I'm sure some other names will come up.

Walter Orr Roberts: A person who had a big impact on me personally was Jerry Tape (sp?). He was head of -- what was it?

Ed Wolf: AUI, I believe.

Walter Orr Roberts: AUI. Yeah, that's right, he was head of AUI and very experienced and helped to give me the insight that I didn't have out of my own experience from his vast range of experience. A lot of the problems that we faced were organizational and political rather than scientific, and of course, you asked a question about science. But we mustn't forget the people who helped with the administrative and political problems, too.

Ed Wolf: Well, I remember Paul Scherer (sp?), who was an early person at the foundation, was involved with us. In the early days he once said it would have been better if rather than calling this the National Center for Atmospheric Research it had been called the University Center for Atmospheric Research. Do you have any views on whether the name made that much difference, and if it did, how?

Walter Orr Roberts: Well, of course, the corporation was always the University Corporation for Atmospheric Research. I think the term "National Center" was important because it indicated that not only were we looking at the interest of the universities but of the nation as a whole, and I would say NCAR, "National Center," was the right name for it.

Ed Wolf: When NCAR got started, what sort of picture did you have in mind about the kind of place this was going to be, the kind of atmosphere that would best foster good science?

Walter Orr Roberts: Well, I think especially at the very outset, we felt it had to be a place that was attractive to people of imagination and intellect in the atmospheric sciences, that it had to be a place where there are exciting seminars, new ideas

being tested out, where people would come and sort of blue sky dream and also in detail and in a sophisticated way discuss the frontiers of science. I mean, pure turbulence theory, ocean/atmosphere interactions even long before we had big computers to simulate things. Try to understand what makes the whole atmosphere tick. And we had loads of sort of dreaming sessions about where the science should be going, and that was stimulating. Even in the earliest days when we had only a few scientists around, we used to have these sessions, and sometimes nothing came of it; other times, big ideas sort of brewed.

Ed Wolf: Right. If you had an opportunity to go back there and revise your vision of NCAR, would it have been any different?

Walter Orr Roberts: I suppose in hindsight you could say so. In the early days, one of the big tensions that existed was the tension which was accentuated particularly when Lee Hayworth became director of NSF. I forget how many years down the road that was, but five or eight.

Ed Wolf: So it was about 1965, I think.

Walter Orr Roberts: Yeah, OK. The emphasis on relevance and relevance to social problems. The great tension was whether an institution like NCAR should leave scientists absolutely free to pursue whatever science they felt most important to pursue from the pure science standpoint, but whether there was an imperative to work on problems that would bring useful products to the nation as a whole and to the science. And I remember Pat Squires made a statement -- I can't remember in what forum he said it, but he said either you must be absolutely first rate, almost in the genius class, to pursue your own ideas totally unfettered, or you must be

very dedicated and committed to relevant problems that would benefit society if you're not that kind of a genius. I haven't phrased it as well as he did, but it was be awfully good or be awfully relevant, (laughs) one or the other.

Ed Wolf: I remember there was a lot of tension in the staff about that. I remember one of the remarks that Chester Newton made about the hail project, which is if he had two lives to lead, he would dedicate one of them to the hail project, but since he didn't, dot-dot-dot. (laughter) What was Hayworth's view?

Walter Orr Roberts: Hayworth was very much in the direction of relevance, but of course he was also under pressure from Congress, which wanted to see the NSF promoting national interest. And I think it was very much Lee's philosophy that - and I held a lot of seminars here at NCAR. I remember for a while, I had a seminar once a week. And I tried to espouse the view that integrated over the NCAR senior scientific staff, something like half of the effort should be devoted to pursuing problems that the scientists individually felt most important and most interesting; the other half should be devoted towards big problems that would benefit society in a demonstrable way.

Ed Wolf: To what extent do you think that model has been followed here?

Walter Orr Roberts: Well --

Ed Wolf: I know there were a lot of people working cooperatively on big projects; they may not be the most societally relevant.

Walter Orr Roberts: I don't know. I think today, the idea of working on problems that are going to benefit society is much more acceptable to scientists than it was back in '60 and '65. Those were the golden years, you know, when there was lots of

money available to do science without quite the need to justify that we see today. But I don't know. Certainly progress in science comes in unexpected ways, and things that you don't expect to have any application at all will suddenly prove highly relevant. Some of the most abstruse -- mathematical theory and number theory, for example, turns out to be incredibly relevant. I wrote a column recently about that Indian scientist who today is still -- what was his name? My memory is failing me today. It was a young Indian scientist who died at something like 22 or so. Came from India, did all of this number theory work, which now, 15 or 20 years after his death is finding application all kinds of places, and he had no applications in mind when he did it, so the right mix is something that I think still should be about 50-50 for an organization like NCAR.

Ed Wolf: When you look around NCAR today, you see a lot of work on problems that are producing in the relative short -- or should produce in the relatively short -- find some useful stuff, starting from the wind shear research and ozone and acid rain and climatic teleconnections and probably two or three others that popped into your mind.

Walter Orr Roberts: Methane.

Ed Wolf: And a great deal of this are things where the connections to societal problems are very obvious and also appear to be at the cutting edge of science. And I would guess that 50% of NCAR scientific effort, at least in terrestrial research, is along these lines.

Walter Orr Roberts: Yeah, I fully agree, and yet I think there's also a pretty good balance of fundamentally important work of a purely theoretical nature that's going on.

Ed Wolf: Oh, a great deal of it for sure. Well, I know you were one of the people who were most enthusiastic about getting the [easing?] program started here, and I was wondering whether you think NCAR and the atmospheric science community in general is doing enough in this area.

Walter Orr Roberts: Well, I think that we are not, actually. I think our [onesi?] program is a good one and has proper goals and all that, but I really think that attention to how you tie scientific results to society beneficially -- I just don't think we do that well enough yet nationally, and the same thing I think goes for what happens here. We have great ideas about how you could improve air pollution, for example, in urban centers, but we're very naïve when it comes to figuring out how you get political support to put the kind of measure that you know from the technical standpoint are necessary, to put them into practice. And I've just come in the last two or three days from a meeting in Berlin sponsored by the Aspen Institute with people from positions of leadership in European political scene and also newspaper people and also from the U.S. Congress and Senate to just look at the interface between basic discovery and bringing it in to feasibly political action. And I must say that in spite of all the best people around the table, it seemed to sort of flounder. The discussion didn't result in any very tangible results except to say that the decision-makers ought to have a longer view than they do. They ought to be looking 10, 15 years ahead instead of two to five years ahead. And

that they should have a better understanding of the nature of science. You know, what are the certainties and what are the uncertainties, and how do you make decisions in a practical way in the face of the kind of uncertainties that exist and will always exist about any scientific result. The ozone problem was discussed at length. And the greenhouse effect was another one that was discussed at length, and the question was, "Was the protocol at Montreal in September strong enough, good enough?" Would it make any difference? Should people spend millions, billions of dollars implementing the protocol, getting rid of the chlorofluorocarbons and changing to other chlorofluorocarbons if the result was still going to be uncertain when you got through as to whether it was going to do very much good. And I don't think that as a nation -- to say nothing of NCAR itself -- I don't think we do enough thinking about that. My own feeling, for example, expressed at that meeting about the greenhouse effect is that there's no way to prevent the greenhouse warming, so let's get on with ways to adapt to it, but that was a very unpopular view.

Ed Wolf: Well, could we backtrack a little bit and let me ask the question: what are some of the achievements at NCAR that have most excited you over the years?

Walter Orr Roberts: Well, I feel that the extraordinary developments of the large-scale numerical modeling of weather and climate have been significant. You might say the removal of the solid barrier between the northern hemisphere and the southern hemisphere in computer modeling, showing the interactions of the southern oceans with the northern and so on, I think that was a major step forward, and now, of course, it's incorporated into actual operating forecast models. And I

think likewise the development of the community climate model has been a major step forward so that people can kind of in a modular way put together experiments using a generic model that is very powerful and runs efficiently on big computers. So those two developments, I think, are among the most significant to come out of NCAR. But there are many, many others. I feel that the work that's been done and advancement of the understanding of the influence of the sun on the earth by the HAO group, and the coronal holes and solar wind and all of that is terribly important, both from the pure theory standpoint and in terms of practical effects of sun on earth. I think likewise the work on acid rain is important and the work on the experimental side of the rate processes of various atmospheric chemistry processes, both urban and in terms of volcanoes and things of that sort. Things like the study of the ozone hole in Antarctica, the part that we played in that. There's a lot that's been pretty exciting going around here.

Ed Wolf: There are some interesting things on the [meteoric?] scale as well, starting with McCarthy's work and going up from there.

Walter Orr Roberts: Yeah, that's right. Obviously the work on wind shear and methods of its detection and prediction. That's not only fundamentally important, to understand how the microbursts occur, but of course terribly practically important for aviation.

Ed Wolf: What about in the technology area, in computing and field observing?

Walter Orr Roberts: Well, of course the work to make efficient use of supercomputers to make it easy for people to present problems and to get into huge databases, I think that's been of very, very great importance, and it has application far beyond

the atmospheric sciences. And then in a whole range of technological areas, there have been many, many clever things -- the balloon launching gadgets, the [pam?] stations that allow you to make sophisticated weather observations in an unmanned fashion and collect the data by satellite. There are just many, many technological advances that have been terribly important. And I think on the near horizon, things like the use of the global positioning system and other methods for improving observations with [drop sans?] and [up sans?] and so on for weather observations to reduce the cost and increase by an order of magnitude the accuracy. I think those technological advances are great, important. Aircraft instrumentation is another for research.

There's another area where I think NCAR has done a magnificent job. Now when you go out on a research mission, at the end of the day when you come back with the tapes from the mission, you can have the stuff analyzed so you know how it went before you start the next day's operation. It used to be that you did a whole summer of research and came home and spent six months trying to figure out what you did on each flight, and oftentimes you found that, My God, you left something out that if you'd only measured it, the whole thing would have been worth a lot more. Now you get that at the end of each day because of new methods of observing and getting the stuff off of the tapes into graphic form that you could look at right then and there. Those things have -- even the use of computer graphics in a real-time interaction with the big computers have made a tremendous difference in the efficiency with which you can look at complex and

large data bodies and complex interactions -- nonlinear equations [and motion?] and things of that sort.

Ed Wolf: Some of the most important things you think NCAR should be working on in the future. Obviously we're not going to be comprehensive. (laughter)

Walter Orr Roberts: Well, I think the implications of the greenhouse effect and development of the detailed regional impact of a global greenhouse warming, I think that's one of the tough problems and one of the most important ones for long-term strategies in agriculture and transportation and urban development and that sort of things. That's one of the most important that I see out in the future. And then a whole area of atmospheric chemistry things -- not only acid rain and not only the ozone destruction but a whole host of more subtle things that deal with the health implications of some of the trace gases. I think those areas demand attention, and I also think very straightforward and technological developments that are partly -- in terms of how people use the technology, like the prevention of jet airplane crashes in microbursts. I think that requires a great deal more effort. And a lot of the effort is on the man-machine interface -- how you present data to an air traffic controller from a technical system of sensors and computers in a way that they can make use of it in a non-confusing operational sense requires knowing exactly how the airplane is flown, what latitude the pilot has, what he can think about in the last moments before landing. It requires a human engineering as well as knowledge of the technical side, and I think there are a lot of examples in areas other than air safety that we should pay attention to.

Ed Wolf: There have been periods in NCAR's history where we've been warned by outsiders that we ought not to get too much involved in the [mesa scale?], particularly those things more directly related to [now-casting?] and short-term forecasting because we would look too much like NOAA. Do you think that's still a problem, or was it ever a problem?

Walter Orr Roberts: I myself don't think that's a major problem. I think the fact that we have established cooperative arrangements with NOAA so that we think about our interface a little bit more specifically maybe than in the past, but that to me has not been a major problem.

Ed Wolf: Because I'm under the impression that the idea that somehow NCAR would eventually wind up in NOAA is something that's a dead issue now.

Walter Orr Roberts: I think so, too.

Ed Wolf: Maybe we ought to take just a minute to break.

(break in recording)

Ed Wolf: Well, obviously the relationship of NCAR and UCAR to the federal government has been a key element in NCAR's success and in some of the problems that NCAR's faced, and I thought you might like to comment on the trends that you've seen developing in our relationship with the federal government over the years.

Walter Orr Roberts: Well, the two things about it that interest me: one is the growing red tape and the other is how you set national priorities. I feel that while I understand the need from the congressional side and from the NSF for accountability and all of that, I feel that the contracts have grown too filled with

restrictions and requirements and paper forms and so on and rules that have to be followed, I feel that somehow or other, an institution like NCAR ought to have a little more freedom to make major decisions that are needed like whether to buy an aircraft or to spend the money in some other way. I just feel that as all societies become hamstrung by excessive legal requirements and legal accountability, I feel that the relationship with the NSF has grown too complex and too many managers and reviewers and accountants and all the rest to allow us to make the best use of our money. It seems to me that we spend far too large a percentage of our time worrying about meeting petty administrative requirements.

I also feel that -- and this is not anything that has to do specifically with NCAR really, but I feel that the development of science policy for the nation as a whole, and in particular, priorities is in a sorry state. I feel that when you look at a project like the superconducting supercollider that's being considered as a national scientific goal and policy item and compare it with certain other objectives like, for example, building a test thermonuclear power facility, that there's really no careful evaluation of national interest in setting the priorities -- one being cut back, the plasma research for producing thermonuclear power safe and cheap, versus a superconducting supercollider for subatomic physics. And to my feeling, the emphasis on the SSC versus the thermonuclear is totally wrong, and I would say that cutting back in areas of -- you know, we have to be careful not to, you know, be special pleading for our own purposes, but I think considering spending money for things like the superconductor supercollider when we're restricting spending money on things like the IGBP, the International

Geophysical–Biophysical Programme, studying how the biosphere is changing with time. I think that priorities for allocations of funds for those different purposes are not efficiently, and I would say not even properly handled in the country as a whole. And this is an interface between planning agencies like the departments and NSF and so on and the Congress and the executive. It seems to me decisions like the decision on the SSC is made almost carelessly. I [have a lot?] more to say on that.

Ed Wolf: That's fine. I would like to ask you about NCAR's relationship with the university community and the outside world in general, which has had its ups and downs over the years. Perhaps the most dramatic episode was the so-called joint evaluation committee episode, (laughter) but that was only one major impulse in that relationship. Perhaps you'd like to talk just in general about NCAR's relationship with the university community over the years.

Walter Orr Roberts: Well, it seems to me that the relationship with the universities has improved greatly, especially more recently. I felt that the time of the joint evaluation committee activities, that we were being over-reviewed at NCAR -- almost nitpicking reviews in many regards -- and that there wasn't a really adequate way of interchange of ideas between the university reviewers who were looking at us in a highly critical fashion and the members of our own staff who were attempting to respond to some of the goals and also some of the criticisms that were coming. I feel that there was a tension that resulted in maybe hyper-critical reviews for a period of time, the tension being over who would get the money in the atmospheric sciences, whether it go to NCAR, the expensive

university project, or vice versa. And I don't think that there was a degree of constructiveness about the evaluation, but it seems to me -- although I'm not as close to it as I used to be -- it seems to me much more characterized as the present kinds of reviews that go on. I feel that obviously an institution like ours, a big one, taking a substantial fraction of the available basic research money in atmospheric sciences, needs to be reviewed, but it needs to be reviewed in a way that's constructive, and it seems to me it's being done that way now. But I think there was a period of time where it was not being done that way.

Ed Wolf: Do you think it was mainly nervousness over NCAR's taking too much of the pie that led to the JEC episode?

Walter Orr Roberts: Well, you know, I always used to think that was the case, that there was a feeling that they really ought to clamp down on us because maybe we were spending money that would be better spent at the universities, and I think they became in some ways hypercritical, setting for NCAR standards that probably the university scientific programs themselves could hardly meet. Yeah, I think that was a difficult period, and I know that I resented some of the kinds of criticisms that were received, and I didn't feel that our responses got adequate attention, and I know a lot of our scientists felt the same way. They felt very bitter about some of the comments that were made about their work, and I think in some instances, perhaps the criticisms were valid, but in many instances, the position and the reasons and the logic of NCAR's activities in these areas didn't get a fair hearing.

Ed Wolf: It's always been difficult to review NCAR because university people tend to want to review things piece by piece rather than the way they fit together.

Walter Orr Roberts: Yeah, that's true. But as I said, I'm not as close to it now as I used to be, but it seems to me that it's very much better these days. I think the university community feels that it incurs benefit, and I think when you take a look at the number of joint papers between NCAR's scientists and the university scientists, you see evidence that the way it was intended to be is the way it is.

Ed Wolf: I'd like to come back to the present and observe that in the leadership in atmospheric science and NCAR, we've jumped that kind of generation gap between the people who got their training just before and during World War II, and then there was a pause, and then people came up in the late fifties and sixties, and now the new generation has taken over the leadership, certainly here at NCAR and lots of other places, too. What's your view of the new generation of scientists compared to the way things were 20 years ago, say, (laughter) in terms of their attitude toward their work, in terms of the level of excellence, etc.?

Walter Orr Roberts: Well, I think just as the olden days, there were people who did it right and people who didn't, I think there are now. But I think the present leadership -- and I mean not only in NCAR but in the atmospheric science community -- is excellent. I feel that the people by and large have the right feel and grasp. There's always a certain amount of narrow specialization and parochialism and nitpicking, but heck, people are people, and the only thing that I feel critical about -- and it's a criticism then and now as well -- is that by and large, people tend to be somewhat narrow in specialization and not

transdisciplinary enough, and not enough concerned about the mechanisms to integrate the results of our work into the needs of society. And also from the standpoint of assuring that things are politically feasible, and also from the standpoint of assuring that applications for their potential actually come into being. Some of the things that we as scientists tend to think ought to be done immediately turn out to be politically totally unfeasible, and you have to understand the nature of political decision-making if you're going to make any progress in those things. And we get impatient sometimes when we shouldn't, but at the same time, we don't really get ourselves sufficiently involved in the needs of the politicians to understand what makes them tick and what constraints they face.

Ed Wolf: Do you see any trends in terms of the younger scientist or in graduate education these days toward turning out broader people who are willing to engage in collaborative research or people who are alive to the kinds of issues you've just been talking about?

Walter Orr Roberts: Well, there are isolated places where this is done. I feel that the group that used to be headed by Gilbert White at the University of Colorado was a good example of the transdisciplinary orientation and good science and orientation towards societal risks and things of that sort. But I don't feel that by and large in typical university departments or in NCAR that there's sufficient attention to that, and I don't see any great trend towards the broader view and towards transdisciplinary science.

Ed Wolf: Does the single-author still have too much prestige in science?

Walter Orr Roberts: (pause, laughs) I don't know. I guess some of the single-author papers are really outstanding and great, but there are an awful lot of multiple-author papers that are narrow and specialized. Multiple authors doesn't mean broad viewpoint.

Ed Wolf: I have seen lots of the evaluations of people where if the number of single-author papers is thought of being a very important indicator of how good the person was. And given the fact that so many things in atmospheric sciences now require collaboration in order to make more progress, I wonder if you considered that attitude an impediment.

Walter Orr Roberts: Yeah, and I think it's characteristic of some of the things that go into -- well, I think the National Academy of Sciences tends to promote the image of the single author and the single individual scientist as being necessarily the great scientist. I think that's an excessive thing, and I think there are many people who have characterized -- you know, have worked throughout their lives with groups of collaborators who as a consequence don't make it, so to speak, to the most prestigious national honor society, if you want to call it that. But then there are major exceptions. People like [Lily?] Alvarez, who's always -- not always, but mostly had a lot of multiple-author papers, and yet receives all the highest honors and academy membership and all that. But I do feel that there is a little bit of snobbery about the importance of single authorship.

END OF PART ONE, PART TWO BEGINS

Ed Wolf: -- in your view is the NCAR experience a good model for other disciplines to foster the kind of research that needs to be done, and if it is, to what extent is it as easy or harder to do this today than it was, say, 30 years ago?

Walter Orr Roberts: Well, I think NCAR is a good model, but I think it would be terribly difficult to create institutions like NCAR today. First of all, there have been quite a lot of such institutions created, and the niches that are open probably are fewer. Moreover, the availability of major funds to create things like this seems to me very restricted, when you think of -- well, what examples can you think of? You can think of creating an institution for the superconducting supercollider, and instead of costing a few millions of dollars in a period of time when science money was relatively free, it's costing billions of dollars in a time when we run national budget deficits, and the costs are so much higher to build an institution. And the niches are rather filled. When you look at building a huge thing like the superconducting supercollider, it's for a rather specialized, narrow field of subatomic physics. To be sure, very important, but incredibly expensive, and compared with the opportunities that existed in atmospheric science, which is a relatively underdeveloped science of great relevance to society, you don't see very many of those niches today open. So I think starting -- in spite of the fact that it was for the time a good model, starting things like this now is very much less likely.

Ed Wolf: Has NCAR been a useful model for the development of institutions in other countries?

Walter Orr Roberts: Yeah, I think so. Not only NCAR, but Brookhaven and Argonne and Kitt Peak and so on -- yeah, I think you're seeing -- for example, the LEST telescope project is a similar thing in a way, and CERN and the European Space Agency -- those are institutions that have developed in a somewhat similar way.

Ed Wolf: Is NCAR and the American Atmospheric Science Community doing enough in international activities?

Walter Orr Roberts: That's a good question, and I think probably not, but we are -- I mean, when you take a look at the role we've played in the Global Atmospheric Research Programme and its follow-ons and in large international cooperation, for example, in monitoring the volcanic activity and things of that sort, yeah, I think we're doing pretty well, but I would like to see more initiatives that involve collaboration and cooperation with Eastern European scientists -- Soviet Union and Eastern Europe. And I think things like the International Geophysical-Biosphere Programme -- you know, monitoring global change -- is something terribly important and needs to be pushed. It's being pushed strongly, but it needs to be pushed much more strongly in my view, and I would like to see bigger commitments, stronger commitments made to it. And I think it's vital to the world, and a great opportunity exists. And to a considerable extent, the United States tries to go it alone on lots of these things, and I think we should be more oriented towards cooperative projects. I would have liked to have seen the

development of thermonuclear test reactors international rather than attempting to do it in one country and then falling flat on our face for lack of sufficient funds.

Ed Wolf: Well, Walt, one last question. In looking to the future -- during this interview, you've talked about things that NCAR and the scientific community ought to be thinking about -- the importance of breadth, the importance of interdisciplinary work, the importance of being alert to the concerns of society, the need for increased activities in the world internationally. Is there anything else you'd add to that prescription looking towards the future?

Walter Orr Roberts: Well, I'd like to see us put more effort into cooperative enterprises that represent humanity as a whole. I would like to see a joint mission to Mars, a joint manned mission to Mars, ultimately, somewhere down the road, that involved Japan and England and the Soviet Union and the United States. Similarly with a manned space station. I think it ought to be on behalf of humanity and not a U.S. space station. And I don't think we are adequately taking advantage of the excitement that such an international enterprise would generate in the public mind throughout the world and the degree to which it would become a unifying factor in the world, a matter of pride for humanity as it looks at the problems and potentialities of our planet and space. I think we could go much farther in those directions, and with what energy I have, I plan to promote some of that. (laughs)

Ed Wolf: That will be fun in five or ten years to see how all that has gone and pull out this interview and see if we want to add anything to it. (laughter) So we'll look forward to doing that again.

Walter Orr Roberts: All right.

Ed Wolf: Thank you very much.

Walter Orr Roberts: How about 25 years from now?

Ed Wolf: Fine. (laughter)

Nancy Gauss: By then we'll be --

END OF INTERVIEW