Dr. Robert Serafin, June 2010

Topics: National Academies NWS Modernization Committee, NEXRAD, ASOS, AWIPS, GOES

Dr. Serafin: I'm Robert Serafin, former Director of the National Center for Atmospheric Research and a longstanding member of the Academies' National Weather Service Modernization Committee, um, during most of the 90s. I think that committee might have been disbanded about, um, 2000. So I would say that that group of people—a terrific bunch of people—whose names I cannot recall, not all of em anyway, worked, uh, hard to, um, advise the Weather Service in NOAA on the modernizations at virtually all steps of the modernization.

My own background was in the field of radar metrology and then later observations of the atmosphere with a multiplicity of, uh, sensing systems. And it was through that background that I was recruited for the National Weather Service Modernization Committee. And it was through the Modernization Committee that I learned so much about the modernization. Um, prior to that, my background in Doppler Radar Meteorology had often been, or at least my advice, had often been sought by the, uh, National Weather Service and Advisory Committees to the National Weather Service related to the use of Doppler Radars, the procurement of the NEXRAD Radars and in once circumstance, which was really not a National Weather Service Committee, but an Academy Committee on Wind Shear to determine whether microbursts, and wind shear were unique atmospheric phenomena that had previously been, uh, discovered and also the degreed which they were detectable with modern Doppler radars. It turned out that they were and that they could be automatically detected and so forth. So an adjunct of NEXRAD Program was the Terminal Doppler Weather Radar Program, which NCAR was also significantly involved.

Regarding the modernization, it was really a very ambitious endeavor. I believe, Dick Hallgren then National Weather Service Director, was truly a visionary in putting this thing together. And it had, as I recall, four principal components. Let me see if I can remember them all. One was a modernization of the National Weather Radar Network. Maybe, I'm not sure that ASOS…ASOS was the surface network or modernization of the surface network for the Weather Service, which I'll come back to this in a moment. A third was a next generation geostationary satellite system, replacement for the GOES. Fourth was restructuring of the organizational ingredients International Weather Service reducing the weather—number of weather stations significantly taking several categories of weather service offices and reducing them to a single category. I think they're called now Weather Forecast Offices, WFOs, usually co-located with the NEXRAD Radars. Um, let me apologize if don't get it all right. It's about ten years or twelve years since I've really thought a lot about this. I've been doing other things since.

Well, um, this was a very interesting, and as I said ambitious and visionary undertaking by the National Weather Service. It made a lot of sense to a lot the community my own views that the NEXRAD was sort of the core of this modernization. Without NEXRAD it would possibly have never have happened. By the way, I failed to mention AWIPS, which was the Advanced Weather Information Processing System, I believe, which was supposed to pull all of the data together at the Weather Forecast Offices. So that was sort of the glue that pulled it all together.

Um, each of these procurements and systems ran into obstacles. Um, it's my judgement that the Weather Radar Network ran into the fewest obstacles during procurement. One of the big obstacles of course is always funding and the availability of funds and the challenges from various elements of, within government, inspectors general and OMB and others as to whether or not these expenditures were really necessary.

There was another component namely that the ASOS and the NEXRADs were—turned out to be, um, multi-agency activities and fundings. So the NEXRADs were funded by the National Weather Service or NOAA, the FAA, and the U.S. Air Force Department of Defense. The ASOS were funded by NOAA and the Federal Aviation Administration. I think that AWIPS became only a National Weather Service system although the Air Force and FAA seemed to have created their own versions of AWIPS. I never was certain whether or not—I never was—it never was clear to me whether or not those independent activities were necessary, whether AWIPS could have done it all or not.

I think the Weather Radar procurement went quite smoothly. Also largely within budget…within the budget. And has turned out to be enormously successful. I think, if you were to speak to head people within NOAA like Mary Glackin whom I got to know through the AWIPS procurement. She was in charge of that while the Weather…while the Modernization Committee was in place. She would acknowledge that it was enormously successful. And, um, and has paid big dividends with regard to short-term weather forecasting. NEXRAD is almost a household word, but certainly Doppler radar is a household word around the country. And there's no doubt that warnings for severe weather and tornados have been facilitated and lead times extended because of those facilities. And they're still active today, useful today some 12 to 14 years after the NEXRADs were completed with next generation—well I should say a major addition about to happen and that is polarization diversity to the NEXRAD radars, which will improve the ability to determine the state of the hydrometers whether they're ice or water, hail; detect hail and warn of hail, and hail shafts. So I think in—and there's another aspect to it that should improve, uh, precipitation rate estimation. So from a hydrological standpoint, the severe storm standpoint, the polarization diversity improvement should be pretty significant.

09:25 Um, during this period I also chaired what was known—it's still in existence, the NEXRAD Technical Advisory Committee, the NEXRAD TAC. And that was a group of people within the FAA, the Weather Service, Air Force, and some at large people specifically Jim Wilson and Paul Smith, and at one time Bringe from Colorado State University were people I invited to sit on that committee to review, uh, future improvements and to give advice on technical improvements and advancements to the system. And that led to significant improvements in the software. I'll come back to that in a minute, the algorithms for interpreting Doppler Weather Radar data; but also to hardware upgrades as the system grew older, the improvements to the signal processors and the product generation, uh, within NEXRAD. And that was an interesting, uh, six years. And it came about at a time when NEXRAD was just beginning to come into operation, becoming online. But it was a great time to be associated with it and it was pretty exciting.

Regarding the software, there were many of us who always felt that maybe NOAA the Weather Service was trying to do a little too much with algorithms that had not really been tested in an operational environment. And I personally felt that it would have been better to maybe not invest quite so much into those algorithms initially and to let them be tested and evaluated online. And in a

sense that's what happened over time. Many of the algorithms have been revised. Some have been scrapped. New ones have been added. So the concept of an evolving system is one that I think proved to be viable and is a way to keep systems from becoming obsolete. The old Weather Radar Network had become obsolete, at least to some degree because of the inability to introduce new technologies and new interpretive systems to the network. Of course the radars themselves became, old and worn out and needed replacement. That's was another issue, of course.

11:45 The AWIP System, um, ran into some problems with the system configurations and escalating costs and whether or not it would do the job. And eventually the Forecast System Laboratory produced, I think, software that was eventually incorporated into the AWIPS, under Sandy MacDonald by the way, that was effectively incorporated. And it also became a successful adjunct to the modernization.

12:35 The Satellite Replacement System was interesting. Somewhere along the line it—the U.S. had become questionable whether we were actually going to be able to get the new technologies to work in time. The old Spin Stabilized GOES Systems were being replaced with Triaxis Stabilized Systems. And I don't remember completely why they had some problems, but part of it had to do with heating of the services in a non-symmetrical way. Another had to do with whether they could get the infrared detectors necessary for GOES to work in the environment. So there were big problems, technical problems. And the costs were also increasing. And the Weather Service Modernization Committee was asked to do a particular—a special study on just that issue, continuity of satellite observations. And I think we did a good job and gave them some good advice. One—some of the advice we gave them related to not taking existing systems out of operation until you know that what you have as a replacement is going to work. I'm not certain that the Weather Service has really bought into that in even today. NPOESS for example; an example of cost overruns and technical difficulties and so forth illustrating that it really is hard to change from one technology to a new one, one that's been tested operational and a new one that has not yet been tested operationally. And I think the Weather Service and NOAA and NASA are still struggling with this issue of the transfer of technology to operations, crossing what has been referred—what is it referred to? The Valley of Death I think is what it's been called by several people in our…in one Academy report.

14:52 Another thing we ran into with NEXRAD is that…uh, was in place was it had to with—and this was a very interesting study—it had to do with the, um, the siting of the radars. The criteria for siting had been coverage at ten thousand feet above ground level over the country. And the issue was brought to our committee because of some Congressional concerns that radars had been near—on the old network had been nearer their constituents were now being moved away. And would there be a lack of coverage or a reduction of services? One of the principal criteria for the National Weather Service modernization had to do with insuring that there would be no reduction in services, no degradation in services. It didn't—there were no criteria related to improvements in services. They all had to do with degradation of services. So there were Congress people that were concerned about the degradation of weather coverage.

And we did something quite different, really established some different criteria in that sub-committee. We talked about the weather phenomena that needed to be observed and were relevant to weather services in the entire country. Obviously, there are no lake effect snow storms in Florida and there are no hurricanes up in Lake Erie and Detroit and Chicago. So the criteria needed to be

different. The depth of the convective storms needed to be taken into consideration. Micro—well the Weather Service NEXRAD is really not being used for microbursts, but dry outflows and strong gusts and so forth would be -- occur in some parts of the country. They don't occur elsewhere.

And so we, first of all, looked at the criteria and tried—looked at the weather of interest in various parts of the country and tried to determine what kind of coverage above the surface or above the radar would be needed in order to make effective observations to those phenomena. And from that we drew some circles for each of the weather phenomena around all of the weather radars effective coverage. Then we did another thing; we went to the Weather Forecast Offices themselves and asked for subjective evaluations, not looking at the height of storms or anything like that. Subjective evaluations of coverage with regard to specific weather phenomena, anything from boundary layer winds to hurricanes to deep severe convective storms. And we got those objective criteria. This had never been done before. It was really quite an interesting exercise and an important one. It turned out that the subjective criteria were somewhat more conservative, but not much more so than…not much different form the objective. And in the end the committee decided to use primarily the subjective criteria in establishing coverage.

The long and short of it is the Congressmen who were concerned their districts generally didn't need to be concerned. We did identify two areas that might need some additional coverage. One was, I think it was in Arkansas. It might have been Fort Smith, Arkansas, but…. And the other one had to do with a radar location up in South Dakota where the coverage didn't seem to be quite enough…quite adequate. We also—I think as part of that study recommended that the —it had to do with the Key West radar whether or not there should be people there or not. Another radar up in the Northeast I think so whether or not they should have people at the radar or not whether that should be associated with a WFO. Well this report was anxiously awaited by everyone; by Congress, by everybody in the Weather Service and so forth. The Weather Service was concerned that they might have to reconfigure the whole network of radars. Congress was concerned that its constituents were not being protected. And with these few exceptions, we found that the network was actually well established, certainly useful, no degradation of services over most of the area except for, as I mentioned for those couple of exceptions. And the Weather Service and NOAA took actions to rectify, as I recall, any of the deficiencies that we found. And I think this is illustrative of how this committee had a real influence on modernization. NOAA and the Weather Service were, well, anxiously looking and awaiting every one of our reports.

20:20 We actually wrote a report once on employee relations. And I don't think that was the name of the report. And the people in the—on staff, non-unionized and unionized employees were watching our reports very carefully because in—they affected their jobs. Our reports could have affected their jobs. I think most people know—maybe they don't—that in part of the reconfiguration or restructuring the Weather Service changed from a service that was about one-third degreed meteorologists and about two-thirds technical support, to about two-thirds degreed meteorologists and about one-third technical support. That was a pretty radical change. It resulted in a lot of hiring, new hiring with the Weather Service as retirements took place. I don't think there were any layoffs or anything associated with that restructuring. But it certainly took place over several years. I know the universities were geared up to train more graduate meteorologists. And then that slowed down. And I think, in fact, their enrollments in meteorology dropped off some after the Weather Service modernization took place.

21:50 Let's see, I've gone through the satellites. I've got the radar. I've got the—the ASOS worked out pretty well I think. There were some questions from time to time. Costs were always a factor. Budgets tended to be escalating. But it seems to have worked out pretty well and is in place today and is in National automated system available throughout the…throughout the country. There is interest today within the Weather Service about, uh—or in a concept, which has been referred to by the Academy as a network of networks. And we touched on that somewhat back in those days, noting that there were—that the National Weather Service Network was not the only service network in the country. For example, the state of Oklahoma has its own Mesonet. I think other states have Mesonets to one degree or another. Other agencies of government have their observations. The Federal Aviation Administration has observations that are independent or in addition to the ASOS.

23:07 This network of networks concept—and there are some private sector networks. It's my understanding that this organization, WeatherBug has thousands of service networks around the country today. The National Lightning Network, uh, that is used by the Weather Service today is actually operated by a private sector company. I'm not sure what the name of that company, but it works—it's very good. It works effectively and gets the cloud-to-ground strokes. In any event the network of networks is something of the future that—in the future that would somehow combine all of these service observations into a single network.

So we got—and then of course the Weather Service forecast offices, that thing worked out pretty well. For every new NEXRAD there was a new weather forecast office, a great working environment for the staff I think and one that seems to be working well for the National Weather Service.

24:17 Barry Reichenbaugh: Can we go back to your service with the, uh, the Modernization Committee? Some of the—you said some interesting things in particularly about the, uh, concerns for the committees reports coming out and, uh, what they would mean to the direction of the modernization. I'm just wondering you could…could reflect a little bit on, how the committee, viewed itself and its role. And obviously there were different pressures. Uh, and you all had a job to do. For instance I guess in terms of budget. If you had come out and…and decided that the Weather Service's choices for placement of radar weren't the best they would have been in a pickle because they would've had to come up with a lot of extra money to fill in the blank areas or move radars, etc. Could you talk a little about the charge to the committee in general and…and how you all either set those concerns and applied your expertise to the…to just weigh in a decision no matter what the consequences would be?

25:40 Dr. Serafin: Sure. Well I think the Academy does a great job. I've been on a number of academy boards. It's more than I can count—um, and committees. And their reports are thoroughly reviewed, probably the best reviewed technical documents that this country produces. And the Academy's work is not going to be compromised. I absolutely believe that it's not going to be compromised by whatever consequences might occur to the sponsor…sponsoring agency. This committee…the National Weather Service Advisory Committee was pretty unique. It probably should better have been called a board because it was in existence for about ten years. And it didn't have a specific charter to do this study. Its main charter in a broad sense was oversight of the modernization. So a lot of the studies that were undertaken by this committee were at the initiative of the committee itself, which is also unusual for, uh, an Academy committee.

27:06 There were some that were specific for example the radar siting. That was a charge directly from the U.S. Congress, not from the Weather Service. It wasn't in our charge. We undertook a study that was eventually entitled Aviation—it wasn't aviation. It was "Weather for those who Fly" aimed more at the FAA than the National Weather Service. But another aspect to the National Weather Service Modernization Committee was that it began to think about weather services, not just the National Weather Service. Its final report was one of the more visionary reports that the Academy has come forward with. And we weren't sure it would be, you know, accepted by the reviewers. At that time Rick Anthes was chairing the committee. And I think he followed my chairmanship, I think that's right. Yeah. And, um—but that was a really interesting committee. And it wasn't in anyone's hip pocket if that's what people might think.

28:37 The Weather Service didn't like a lot of what we said. But in the end it was good for them. It was good for the modernization and maybe without the critical reports that were written. We were oftentimes quite critical of things that were being done. It might not have succeeded. It might not have gone forward. We, also as a committee—because of this kind of unique charter our reports were not put on shelves to gather dust. The Weather Service responded, and we asked for a response. We wanted to know what they were going to do in response to recommendations and suggestions that we might have made or findings that we had made. And we got those responses. And, as I said, they tended to do a lot of what we recommended. There were times they would say, 'this is not what we are going to do because...' I mean one can understand that. So I would say that, um, it was a committee that worked pretty well. It worked within the Academy framework. And the Academy framework is one that tends to be very objective and the reports are exceptionally thoroughly reviewed. So I was very happy and content with the work that the committee did and willing to defend it as being objective and thorough.

Another thing is the committee, because there was so much continuity among the committee members—I would say that the committee members knew more about the modernization than a lot of people in the Weather Service for sure and a lot of people who were associated with the component of the modernization, but not all of it.

30:45 Barry Reichenbaugh: Can you talk a little more about the collaboration on the research and development side thinking, I guess, about,—well for instance we're here in Boulder, Colorado. And I know that work was done at, uh, the Forecast Systems Lab. What were some of the other collaborative pieces there?

Dr. Serafin: Well some of them are, um, they're not formally connected. But when I think about before NEXRAD was approved, there was a program called JDOP, the Joint Doppler studies at Norman, Oklahoma, to demonstrate that Doppler radar could detect tornadic circulations in the storms. And leading up to that was, several years of research within NOAA at the Severe Storms Laboratory, but also here at NCAR. NCAR was developing a very capable Doppler radar research capability. And I was the head of that. That's why NCAR brought me to Boulder in 1973. I led that Doppler radar development activity here. So there was a heck of a lot of work being done with single and dual Doppler radars. And those radars, the NCAR radars were also a part of the JDOP studies with universities, NCAR scientists, NOAA scientists all involved in the examination of wind field structures, circulations in severe storms, and the ability of Doppler radars to be able to detect these things in real time.

32:40 A lot of that came about as a consequence of Display Technology. One of the things I'm very proud of was that NCAR made this decision with our data processing and Chief Engineer, Grant Gray, to use new technology—and I'll go back a second…a bit farther in a moment—to use new technology that was available in the form of integrated circuits. These were kind of slow integrated circuits, but we were able to multiplex them, that is to use several in parallel to keep up with the raster scan speeds of TV tubes, color TV tubes. And by doing so we created the first color Doppler radar display here at NCAR. And in a storm here in Oklahoma, I mean in Colorado, Dave Atlas, my boss and dear friend —well he came to NCAR and hired me. But, Dave was able to identify circulation in a supercell storm in Colorado, Northeastern Colorado. I'm sure that was the first time it was ever seen on a color Doppler radar display.

34:05 So that kind of technology fed into what was happening in 1978 I think it was, 77 or 78 when that JDOP program took place. And that program established the feasibility for the next generation of radars and namely the feasibility of adding a Doppler capability to that network because it had to be replaced one way or another. But this demonstrated the feasibility of, uh, a Doppler capability. And that led to the concept of the National Network of Doppler Radars, Doppler Weather Radars. So that's I think a really good example of how research fed at least knowledge gained to various organizations fed into technologies that were eventually implemented. To this day, research in laboratories other than NOAA labs is feeding into the evolution of the network of the radars of the NEXRAD Network.

35:20 The —I don't know much about satellites personally and satellite technology, but certainly research at NASA with universities involved has led to some new technologies implemented within the operational satellites that the nation has. I think we did as a committee recommend this merger of the Air Force and NOAA into a single operational polar-orbiting satellite network. I don't know if that answers your question. That's one example of — but I think that NOAA has paid attention to, the technologies as they've evolved through the years and has tried to take advantage of technologies when they make sense. There are a lot of people and many organizations who are, of course, promoting their technologies for operational use. In some cases it happens. In some cases it doesn't. The National Lightning Network is a good example of how the, Weather Service has taken—not reinvented the wheel, which is sometimes hard for the Weather Service or any organization to do, not reinvent the wheel—and just bought into an existing technology and used it.

36:56 Barry Reichenbaugh: I think we've pretty much covered what I wanted to try and get. Uh, is there anything else you'd like to add?

Dr. Serafin: Well I think it was—you know it was a new paradigm the way, the Weather Service went about this and, as I mentioned, a lot of obstacles throughout the government. I think in some cases the private sector where the private sector wanted to be sure that its role in weather services or its roles in weather services would be preserved. The Weather Service opinion was that they would not only be preserved, but enhanced. I think if one were to look today at the role that private sector companies have in weather forecasting you'd see that it's an expanded role compared to pre-modernization. I can't prove that, but I think so. I think that industry has been growing and, …and it's the consequence of improved information that they actually get from the Weather Service. They have better access to the NEXRADs than they ever had to the old radars. I think that all those data are available to just about anybody who wants them. For a while the NEXRAD data were being

available through the private sectors through contracts. I think there three contractors who provided the data to anyone who wanted them, but they had to pay for them. I think today the data are available without charge. Is that right, Barry?

Barry Reichenbaugh: My limited knowledge of that is I believe it was constrained of the dissemination of the capabilities of the time that, you know, that is a huge batch of information just the pipelines weren't big enough to handle it on the kind of basis that we have now. But you've got the World Wide Web and you've, you know, just an increased speed and…

Dr. Serafin: Yeah.

Barry Reichenbaugh: …transmitting data now. That's my understanding of it.

39:00 Dr. Serafin: And by the way there was another—it is an interesting area, um, evolution of the NEXRAD that is getting real time NEXRAD data to people who might want it for research or even to other weather forecast offices around the country instead of just products. And the University of Oklahoma really led in that arena by taking a look at data compression; how much this data could be compressed and sent over a lower band width lines. And that worked out really well. I think Kevin Droegemeier at the University of Oklahoma is the person who really, pushed that very hard and got it to happen. And that resulted in much easier access to real time data from NEXRADs for research and for operations.

40:01 The—maybe one of the lessons to be learned through this Weather Service Modernization Committee is the modernization must have been at least a four or five billion dollar effort I would guess. And I don't know what was spent on the committee, but it wasn't anywhere near that. I assume probably a million a year or something for ten years, a relatively small investment in comparison to what the Weather Service was going to spend on modernization. But I think it paid off. And one of the reasons it's paid off is because of the continuity. As I mentioned before, the people who were on that committee were really committed. They came to the meetings. They had an interest in what was going on. They knew technically and scientifically what was going on. We had people who understood the human relations, the employee relations part of it; the committee was strongly committed to human engineering to be sure that the systems that were going to be procured were actually going to do the job and be useful to the engineers, scientists, meteorologists. We had a lot of interactions with the operational people. So something like that, that kind of a committee has a lot of value.

41:39 Managers--Program Managers don't really like advice, not that they don't understand it in an intellectual sense that it's useful. But advice is troublesome. You've got to respond to it. You've got to, in some cases find the money to do something that needed to be done or needs to be done and in some cases stop doing something. But in the end I think it's beneficial because people who are too close to something, intimately involved, can get off the track a bit from time to time. And, uh, good knowledgeable people can help them stay on the track.

42:30 I'd advise anyone who is interested in this modernization to take a look at that final report of the committee because it was a very interesting report. It was written about the year 2000 and now its 2010. And it talked about what weather services would be 25 years in the future – that's 2025. And, um, while I haven't done an objective one-to-one comparison of some of the blue-sky thinking

that is in that report, as I see what's being reported to the public today in terms of weather forecasting and weather services, it's a dramatic improvement over what we had ten years ago.

The—one of the things we talked about was higher resolution focusing on people who are most likely to be affected the most by whatever the weather happened to be. And there's no doubt that that is now apparent. In our own forecasts here in the Denver area on TV there must be ten minutes out of a thirty minute newscast that's devoted to weather. Ten years ago it would've been two minutes. And now we see very detailed radar presentations of where the severe weather is and who it's affecting and how, and where the storm is moving. The warnings are much more specific and precise than they were ten years ago. We see airlines taking action on the forecast. They didn't do that before. They'd wait for the snowstorm, even in severe storms as we had last winter, the snowstorms. They'd keep flying until they could no longer fly and then stop and the chaos would occur. Now they're taking actions that make a lot of people unhappy. They're cancelling flights in advance, but it's probably in everyone's best interest that that be done, um, from a safety standpoint, from an air traffic control standpoint, from an efficiency standpoint, from a convenience standpoint. Although it may be an inconvenience to be told your flight has been cancelled. It might be a greater inconvenience to sit around an airport for 24 hours.

45:05 So I see a lot of what we were talking about then happening. And super computing; that was an element, of course, of the Weather Service that was always there, but we strongly supported state of art super computing along with modern data assimilation techniques for forecasting. We're seeing more and more of that, finer resolution models. It was I think a very exciting thing. And Dick Hallgren really, you know has to be commended. I think everyone recognizes how important his vision was. We were taking that on. It wasn't something easy to do. It's never easy to do good things, to break away from a paradigm to say that we're going to take some jobs out of this Congressional district and move them into another because our radar forecast office is moving. That's you know politically big challenges. Technically there were big challenges. Organizationally: internally, externally there were big challenges. I was really happy to be a part of it in a small way.

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