Carl Bullock, June 2010

Topics: PROFS, AWIPS Requirements

Carl Bullock: My name is Carl Bullock. And I was -- I have been an employee in NOAA. Actually hired on in 1972 and retired in uh...January of 2010. And I started my career as a meteorologist intern. I actually did a summer in Billings, Montana and then came -- came on board full time after graduation in '73. And my first duty assignment was in Bakersfield, California as in a meteorologist intern position there. And uh...about a year -- after about a year I moved to Salt Lake City in the scientific services division there in Salt Lake City at the regional headquarters. And spent um...let's see, that would've been '74. Probably spent about three years there in regional headquarters and then moved out to the forecast officer there in Salt Lake City. I think I was officially out there in late '77. And held various positions there at the forecast office until I guess I'd have to look to be sure, but '82 or '83. And then went back into the regional headquarters in oh, I think it was '83. No, it was '82 in the meteorological services division. Then came over to what was the PROFS -- Program for Regional Observing and Forecast Services in 19 -- the fall of 1984. And uh...ended up staying here the whole time, the remainder of my career.

Barry Reichenbaugh: Can you talk to me just a little bit about uh...your introduction to PROFS and what was being done? In other words, you worked in a forecast office, so you had the day to day uh...experience there in regional headquarters. So if you could talk some about that.

Carl Bullock: I guess uh...I have a somewhat unique perspective. And Denny came out of pretty much the same timeframe, same vintage. We -- when we started in the weather service, we were based on teletype and facsimile charts. And then we saw the introduction of the AFOS System I think Salt Lake City. I'm thinking it was '76 or '77. I'd have to check on the dates to be sure. It was you know, the AFOS System was a -- was a good step forward, but the technology. I think Popular Science actually wrote an article about this last year or so talking about weather technology being the twenty-fifth on their list in terms of the amount or of the -- the amount of change in the degree of acceleration that had occurred in technology in weather related applications. So that really started even back in the seventies.

For a lot of us, one of the seminal events was the 1976 Big Thompson Flash Flood. And I think a lot of -- a lot of us will trace -- trace-- trace the beginning of the modernization to that event. I think it was within a few months, or maybe it was in '77 when they -- there was a joint meeting between the ERL at that time and the National Weather Service talking about what could be done to improve the system. It was clear that uh...besides the human errors that existed at that time, the technology was not adequate um...to provide the kind of warning that was needed. And uh...there was much better technology that had -- that was on the -- on the books. And being developed, and even somewhat in the field at that time.

4:18 Tthat led eventually in 1979 I think, to Weather Service and ERL jointly starting the PROFS program. I think it was October of 1979. Having been stationed in Salt Lake City, and working

quite a bit in the scientific services division also for personal connection with Sandy McDonald. We were in school together. He actually was finishing his graduate degree while I was completing my undergraduate. So he was my lab instructor in Salt Lake City. And after I came aboard in the weather service, he was still finishing his graduate degree. And then he came on board with the Weather Service, and we worked together some in the scientific services division doing uh...doing some training video tapes and some other -- some other work. Anyway, Sandy came over at the -- at the outset of the PROFS program. He came here in '79 and I was still in Salt Lake City. Then in um...it must've been '83, I came over. No, it must've been '82. I think it was RT83, but it might've been the RT82. I think it was the RT83 experiment. Uh...the PROFS program would run an experiment during the summer where they were taking the new technologies and applying them to the severe weather forecast prob -- problem. So we had an experimental Doppler Radar. The people at PROFS had an AFOS system, and they were developing uh...systems based on digital equipment, uh...computers, and Ramtek displays when I was involved working with different kinds of human interfaces and whatnot. So I was uh...able to come over as a from Salt Lake City from the regional headquarters I think at that time to participate in those experiments. It was a real um...for me it was a real eye-opener to see what could be done. I think we had uh...we had the Doppler -- experimental Doppler radar. We had a pretty good system uh...computer system that was pulling in satellite imagery and the radar imagery. We had a mesonetwork that I think went in probably in 1980 here, the PROFS mesonet. We were working on some numerical models that were more geared for short-term rapid update cycles.

7:05 So we had all of the -- the pieces that were together in the RT83 experiment. We had researchers from ERL involved uh...pairing up with the forecasters from the field. So that was a great uh...two week stent I think that I did here. I can still remember seeing my -- seeing some thunderstorm coming off the front range here. Seeing my first folded velocity as we had kind of a bow echo coming at us, and it took me a few minutes to figure out what -- what I was looking at on the radar screen because you know, it had folded and it had gone into the other direction. I wasn't prepared for that when I first saw it. So...but it was clear after the -- after the two-week exposure that these were -- these were gonna be really valuable tools. It was gonna happen. It was going to be uh...something that would really help predicting severe weather, severe thunderstorms, and tornadoes in particular as well as flash floods.

So I had that kind of seminal experience here at PROFS. And I immediately set out trying to apply for positions as they came open here in PROFS. And I remember one of my colleagues asking me why I wanted to come over here. And uh...my answer to him was well, that I can really see the potential of -- of the new technology and getting applied properly in meteorology. But I had also been in the Weather Service long enough to -- to see that sometimes those technologies, the realization as the -- as it was being developed and deployed would get off track so to speak. So they would make some decisions based on what I -- what I -- what I would term non-essential requirements that really limited the value of that system in applying it to meteorology. So I felt like

I could come over and be part of that, and help ensure that what actually got out to the forecaster was gonna be something that would be really useful and helpful to them. And I expected that was gonna be maybe a five-year proposition to get everything going.

So we came over and we're working very closely with the weather service. And we had set up a second experiment in 1985 called RT85. Uh...so I was over here and part of ERL by that time working with it. And uh...the Weather Service said this has been really valuable, really great. Um...I need to backtrack now. But anyway, they said that we -- we would like to put a prototype system in a forecast office. Not just a -- a limited time experiment, but actually have it running in a forecast office through the four seasons to see how this technology will -- will benefit the National Weather Service.

10:29 Uh...backing up a little bit on that, the AWIPS requirements process got started in my recollection as it was 1982. And Mary [Glackin] might have a better recollection of that. Mary and Fred Zbar were the ones in charge of that. And I was part on the Weather Service side, part of the group working on the requirements. We had a representative from each of the regions. And I was the representative from the Western Region. So we were specifying all of the requirements through a series of -- it took a fair amount of time to develop all the requirements. And really it was a consolidation of what had been done in PROFS, what had been done with the McIDAS System at the University of Wisconsin. That was a very important uh...um...ingredient.

Barry Reichenbaugh: Can you? Sorry to interrupt you, but can you uh...explain a little bit about what some of those basic requirements were uh...so we can capture that?

Carl Bullock: Well we still have those old requirements documents. And uh...they eventually ended up being what we ended up calling the “twenty-two thousand shalls.” So the system shall do this and shall do that. And...

Barry Reichenbaugh: Wow.

Carl Bullock: And everybody was loading on. And this is typically what happened. This is why I say sometimes a system will go awry. Because people will just come in out of the woodwork with all kinds of requirements. They're legitimate requirements, but there's no sense of what's really most important, what has to be done, what's essential, and what is something that can wait or something that really isn't needed. It's a -- it's a lower level requirement.

[Pause in recording]

We were talking about the requirements process that started in '83. And I was mentioning that that really was strongly influenced by the systems -- the prototype systems that had been developed uh...at that point in time.

One of them was the McIDAS [Man-Computer Interactive Data Access System] System. I was introduced to that while I was a graduate student at the University of Wisconsin. That was probably the preeminent system at the time. Uh...a version of that was running at the SPC [Storm Prediction Center]. Uh...they had done some experimentation with uh...new radar systems down in Norman. So there were all of these different uh...aspects. And then people just from the various um...programs in the Weather Service, bring to the table the requirements that they thought would be appropriate for uh...for a new and more modernized system. So that included NCEP. Lots of requirements from NCEP. Uh...they were using the uh...wasn't N-AWIPS back then. It was I guess a version of GEMPAK to -- to look at that model data.

So we had a number of systems that were tending to be specific for one particular kind of information. McIDAS was very focused on satellite imagery, although it had other -- could display other information. GEMPAK was very focused on the model data. We had some radar display systems down in Norman, but they were -- they all tended to be disparate and tended to focus on one particular type of information as being the most important, the predominant. So anyway, that's the requirements process. We can that continued on for probably two or I think, we had a first -- a final version in 1985 or 1986. Well I had one in 1984. So that was some process that was continuing on at that -- at that point in time.

14:22 My role as I came to PROFS was to really filter that set of requirements. We -- we got directions from the Weather Service about what they wanted to work on in particular. And so my job was to go through those requirements and filter them down to something that was doable, and that would address the particular areas that the Weather Service was interested in at that -- at that point in time. So I would -- I would go through and uh...go through all the requirements. And I'd be tossing out a lot of things. Uh...we didn't spend a lot of time working on uh...tide information or oceanographic data for example. We were really focusing initially on -- on the severe weather problem. And then as we went in after the RT85, we were looking to... The mandate was we want to have a system that will support the public forecaster. So that one will include the severe weather operations. And that will include the zone forecast, and the other -- the other public forecasts. We were leaving aside all of the aviation, all of the fire weather, and all of the other programs. We were just focusing on those -- on those items. And that meant we needed also to have a connection with the AFOS System, so that they could use the system to actually produce their forecast and sent it out. And that became known as the uh...DARRRE. D-A-R, and the R was three Rs. So R cubed E. It was the Denver AWIPS Risk Reduction and Requirements Evaluation System.

We ended up installing that -- that system in the Denver forecast office, um...in the fall of 1986. And we -- we started, and we would run -- we ran that system through the actually until it was replaced uh...about three years later. Uh...and that proved to be very -- a very useful, very successful system.

16:38 One of the things that was going on at that time that likely won't -- that I'll mention unless they get overlooked or passed by. Um...that's sort of the political dimension that goes on on these developments. The AWIPS System was uh...the term was AWIPS 90. The intent was we would have it in operation in uh...we thought in the early nineties. It ended up being pushed back until the late nineties. But uh...those are programs that uh...last over many years.

And consequently, they run into a variety of political uh...administrations. Different administrations and different uh...administrations with different emphases on what's important. And what turns out to be a very important aspect of -- of the demonstration systems that we put in that we developed is this political dimension. Uh...we had this occurring somewhat with the DARRRE 1 system, but it really happened a lot with the DARRRE 2 system that we put in… into Denver in 1989. So the DARRRE 1 system was just uh...the public forecaster. The… all of the data was still supplied out of um...the PROFS system here. So we would -- we basically had a system that was remotely connect -- connected down on the Denver Forecast Office. So we would send all the data down, and it would run there in the office.

18:27 The DARRRE 2 system, the -- the emphasis there was "okay we want a system now that will support all of the programs in the office. So we want to include the aviation. We want to include the hydraulic -- hydrologic program. We want all of the -- all of those programs supported." So that was the DARRRE 2 system. And there again, most of the data was originating here in -- in Boulder, and being sent down to the system.

18:58 We had a lot of visitors from… Congressional staffers and various committees that would come in. And we knew as they came out, that they were really coming out with an axe. They wanted to find a way to cut this program. They thought it was uh...too expensive. Uh...it wasn't -- it wasn't worth the time and the money and the effort that was going into it. One of the really satisfying things that happened is as they would come out; we would set up uh...tours for them. And but the most important part of that was spending some time in Denver with the forecasters sitting at their elbow. And uh...we were very fortunate that most of the time there was active weather going on when they would come out. And as they came out and they saw the forecasters working with the data. They saw the satellite information. They saw the radar data. They saw how the forecasters were actually able to use it and issue warnings uh...to a person. They would return uh...convinced that this was really worth the time and the effort that was going into it. So that's one of the hidden benefits of having a demonstration system. That all of the political oversight that takes place, uh...you have an opportunity to demonstrate to them the real value that there is in the program. We didn't have to sell it to them. We would just explain what was going on. They would go down and see first-hand uh...how important it was and how much benefit could be gained. So that was the DARRRE 1 and the DARRRE 2 systems. So again, each of these -- in each of these cycles, I would be going through, sifting through the requirements and picking out the ones that uh...that we could

do and that would give the Weather Service the experience that they were looking for with the prototype or demonstration system.

21:00 Doug Sergeant was one of the real key people Lou Boezi also. And uh...Doug basically had -- had a roadmap in his mind of how we should go about this. He also had been involved with systems development in the past. He was the head of the system uh...Systems Development branch in the Weather Service. And he uh...had he envisioned a progressive approach here -- a progressive roadmap. So we started with just the one function -- the public forecast function. We went to all the office functions. And then uh...Doug said "this has been great. What we need though is we need to get the Weather Service ready for -- for the real AWIPS system. In order to do that, we have to have uh...we have to have NCEP providing the information in the way that it's gonna be provided for AWIPS. We have to have all of these things running out of the Weather Service to be prepared for the AWIPS system.

22:12 And the other big piece that was missing at that point in time was the new WSR88D system. So we went and did a -- the Weather Service asked us to do a third system which went to Norman, Oklahoma. That system was going to interface with the first um...deployed version of the WSR88D radar. So now we were -- we were talking about a system in Norman that was not gonna interface with -- with Den -- with Boulder. So we weren't gonna be able to prepare the products and simply send them down. But all of these other entities had to prepare their information in the way -- in the format that was uh...envisioned for AWIPS. And then provide it to this -- to this system in Norman. So I meant we had to interface with the 88D, and with NESDIS [NOAA's National Environmental Satellite, Data and Information Service] and with NCEP and with all of these other entities. So it was a very smart move on -- on his [Doug's] part to kind of push that into -- into reality. And that was a huge trust. So we developed the what we call the Norman, or the pre-AWIPS system.

23:41 At the same time, the Weather Service was very interested in seeing how these new systems now were going to; what the effect was going to be on their operations. On modernized, what they envisioned as modernized operations. So there was a whole modernization risk reduction that was set up around the Norman system back in the early nineties. Lots of groups looking at each of the -- each of the different programs and doing evaluations. Uh...thorough, proper evaluations of the -- of the different services that were being provided. So it was -- it was a very important and I think a very good move.

24:29 So that was the Norman system. We had lots of growing pains with that. Lots of times when people were saying that they were providing it in this format. Well, it wasn't exactly right. It wasn't quite the way that the documents had specified. So we had to go back. We had to work with them and change the documents and change the formats. And there was a lot of uh...growing pains that went on with that Norman system. One of them was the fact too that we had uh...our experience

here in the Denver area with the Doppler Radar translated about ninety percent of what was -- eighty or ninety percent of what was needed.

But Norman -- the guys of Norman had had a different uh...set of experiences coming forward. And they had some other requirements that we had not treated very well. The one probably most important one was how we -- how we treated -- this will seem like a small thing but it was very important. When we -- when you zoom in on a velocity image, you have to maintain the -- the integrity. You have to go back and refresh on screen from the raw data, uh...what's being viewed. We weren't doing that. We were doing pixel replication and some other things. And it really was not satisfactory. So that was uh...we had a whole learning experience there that we had to go through. And we had to redesign how we handled the -- the radar data as a result of those requirements coming in.

Barry Reichenbaugh: In the nineties when you were at that stage, um...I know personal computers a lot of the technologies were just really starting to gain some momentum. Were you -- were you kind of uh...having to wait for some of that to catch up to what you were trying to do?

Carl Bullock: That's another -- another aspect of the story. So we, I'll finish on the Norman part of it. We -- we did make those changes and those adjustments. We did working with the forecasters in Norman add new features and new -- some new capabilities to the systems. So such that they were able to use the system and -- and they were satisfied with the how things worked. During all this time, we had -- we had worked with DEC [Digital Equipment Corporation] and Ramtek equipment. Because that was what was available when we started this back in the early eighties. Well, uh...the world of technology had changed drastically. The world of personal computers had been developing in the meantime. Um...the world of scientific computing had gone very strongly with the -- the Unix operating system. And there are a number of vendors who were -- who had made that available. Uh...such that the DEC and the Ramtek really were pretty much obsolete by the time we -- we got to the mid-nineties.

I'm trying to remember exactly what the right date is here. I think it was December of 1992 when the contractor was selected to build the AWIPS system. And that was the PRC. So that was a -- that was a problem. Because all of our software, all of our system development had been on DEC and Ramtek. Clearly, those were not -- those systems uh...were on the wane by the -- by the early nineties. So PRC chose instead to go with the Hewlett Packard system -- Hewlett Packard Unix based systems. So suddenly all of the software that we developed was off to the side, kind of obsolete.

28:43 Okay, so what happened then? Denny...was called back to -- Denny Waltz was called back to headquarters for -- for a year to work with Lou Boezi, to work with PRC. Uh...they took uh...software that had been developed in Alaska. And here I'm gonna be a little bit fuzzy, 'cause I can't remember what they called -- what the name of that system was. But anyway, it was built on --

it was running on Unix computers. And they uh...paired that with some -- some software from PRC. And they developed what was called a pathfinder system. So that was a -- an early forerunner of what AWIPS was supposed to be like.

In the meantime, we were working closely with PRC as they started to develop their system. And we had people working with them in various committees and various groups. And as -- as things started to progress long, we started to see this -- this old uh...problem of requirements rear its head where PRC was gonna be held to the twenty-two thousand. Uh...the systems that we had developed, I had filtered the requirements down. I don't remember how many requirements we actually ended up with in the Norman system. A good big chunk, but not all twenty-two thousand. PRC instead was gonna be held to the twenty-two thousand. Well they had no way of knowing what was gonna be really important and what wasn't gonna be that important. And you know, what -- it turns out that in system development sometimes you have a requirement that's not -- not a primary requirement. But it's one that will drive the system nonetheless. So sometimes you have to say well, we're gonna hold that one off to the side. We're not gonna try to do that.

30:39 Anyway, um...as we went along the path with PRC we kind of became more and more concerned at some of the decisions they were making. We would tell them well, you know based on what we -- based on our experience uh...this probably isn't the best approach. This isn't gonna -- I don't know if we said it wasn't gonna work. But we said you know this isn't the best way. We would frequently hear back from them, don't worry. Trust us. We know what we're doing.

Well, eventually they -- they came out with a AWIPS Build 1 and Build 2. And these were systems that were not going to be well received by the field. The user interface was very cumbersome. They were uh...the system was going to be developed using relational databases. All of the data was gonna be in relational databases. And that made some parts of the Weather Service very happy. The hydrology side was very happy with the relational database. That was one of their requirements. But um...it just was not going to be adequate to support severe weather operations. It was just gonna be way too slow. And even to -- even routine forecast operations, it was gonna be way too slow. So uh...the leadership in Weather Service, you know we were telling them we have a problem here. And -- and they were taking it to heart. And they said okay, we would like you to develop an advanced version of AWIPS -- an experimental system, an advanced version. Go after some of the requirements that are not gonna be in the initial system that PRC is developing. And so we did. We -- we basically went back to the set of requirements that we'd used in the Norman system. And we worked very hard to develop that here as a parallel in a -- in a parallel effort. Now that decision was made in -- in May of 1994. And we were tasked to have an operating system running on the… using all of the commercial software that uh...PRC had chosen, using the hardware that PRC had chosen. So we were -- we were asked to run on their system basically, but with an advanced set of capabilities.

We uh...had an experiment with that in the fall of 1995 where we brought in forecasters and exposed them to what we had developed. And this was a fairly thorough one. We actually were using uh...a fairly large set of requirements including um...an ICWF [Interactive Computer Worded Forecast] type approach where we were asking the forecasters to do a digital forecast and then translating that with some software from TDL [National Weather Service's Techniques Development Laboratory] into -- into operational forecasts. And it turned out that that -- that piece of it was not ready for primetime. The other parts of it, the forecasters said you need to make some changes, but this is really in good shape. Move ahead. And so we put in place in Denver, an early AWIP system in the uh...spring of 1996. And uh...this was truly a prototype, so assume it had some glitches in it. So we had some -- you know we had some scary moments with uh...with the system not doing what it needed to do. But we -- we worked through those in 1996. And by -- by the summer of 1996, things were operating I think pretty well, pretty smoothly.

34:34 And then we come to the big, big decision point. Uh...PRC is working along with their system. They're coming up with a -- with AWIPS Build 2. Uh...we have our system running in Denver at that point in time supporting all the office functions with advanced capabilities. Really focused well for the severe weather problem. We had a kind of a closed door meeting, I guess for lack of a better term. Uh...Joe Friday who was the head of the Weather Service at that point came out. This was in August in 1996. And we showed him what we had developed at that point in time. Uh...he talked with the -- the people in charge of the AWIPS program about how PRC was doing. And he basically made a command decision uh...to halt the PRC development and to uh...make the FSL software uh...the new AWIPS system. It was called Build 3. So that was um...caused some consternation in some quarters of the Weather Service. Because they have been working along getting ready for the AWIPS system for the uh...for AWIPS Build 2. And they have been developing their system with that software in mind. And now they had to -- had to pull back and start anew. Start fresh with a different version. We had to -- we had to work very hard. The system we had was really designed for um...was really focused on Denver. And we had to retool the design so that it would accommodate all of the other offices around the country, including uh...the uh...RFCs [NWS River Forecast Centers], and NCEP, and some others.

36:48 Um...so we had -- we had a big chunk of work. But that -- that became the basis of the system. AWIPS Build 3, and then as we retooled and started to work -- work in some of the additional requirements and some of the new capabilities, that became Build 4. And that's the one that actually started going out. Build 4.1 and 4.2 actually going out into the field as AWIPS was deployed.

37:07 There was set of requirements that was still not part of the system, called deferred capabilities. That had to do with the ICWF type of forecast. Um...so we -- we were under the gun. At this point, but this point in time actually I think going back to 19 probably '96 or '97, the AWIPS program came under very intense scrutiny from the -- from the government. All kinds of oversights,

GSA, and all kinds of oversight committees were came in to say this -- this program is in trouble. It's not meeting its deadlines and its objectives. And uh...we were able to start fielding the system with the capabilities sufficient to actually support operations in the -- in the field. So we were under very intense scrutiny. And uh...I think we were able to pass muster it at each of the -- at each of the way points. I think there was a point where we had the IG [Inspector General] and the IG had a pretty negative report on what was -- what was going on. But we were able to -- we were able to bring out the system and that was based on the old system if I'm remembering right. We were able to bring out the new system and show them that yeah, it really was able to do what needed to -- to happen to support fore -- the forecast operations.

38:52 Uh...so that was a lot of work there from really starting in '94 and running all the way until we had the system actually deployed in '99. We had to come back and make some tools. We had to add a system called the LDAD [Local Data Acquisition and Dissemination] system, where local data was then able to come in observational data, upper air data. Um...we had to continue to build a new interface for the 88D [Doppler Radar] system, because the one that we built originally was again on old technology. We had to build a new one. And uh...there was a lot of back and forth on how to do that. Should we do it? Should PRC do it? And we ended up uh...I think making some -- making really I guess excellent progress.

And the Weather Service, I think the strategy which was correct was do we really want a contractor system in the middle of a government developed system? Two government developed systems where we had the 88D? And then -- and then actually that wasn't government developed. That was developed by Unisys. But anyway, do we want to have two contractors kind of arguing with each other pointing fingers about where the problem lies with your primary warning system? So they opted instead to use our system. They actually had a, oh it was a group that did that. They had an independent group. I can't remember who did that now. Come in and evaluate the PRC developed system and our system. And they just -- they -- they decided that our system was further along and in better shape, and had a better uh...it was more open in terms of being able to. I think the PRC system had some proprietary software that was involved and so -- so anyway, they gave the nod to our system. And we rolled -- we rolled out with our system.

41:03 One of the important milestones came in May, early May of 1999. We had just replaced the uh...the Norman system. We had been running the systems in -- in Denver. I think we pulled out the old DARRRE2 system. And I think we pulled it out in 1996 with the -- with the early AWIPS system. And we pulled out the Norman system, the pre-AWIPS system down in Norman. We pulled that out in; I think we must've pulled that out in early '99. And uh...so we had the -- had everything in operation.

And then -- then the uh...tornado outbreak hit Norman in I think it was May 3rd, 1999. And that was the real, a real acid test for our system. I remember, Denny can probably give you even a little more detail. But we just -- we had discovered some problems with the way um...information was being

exchanged and handled in the radar system where it could begin to fall behind. And we just put some new software in the week before. And we were really nervous about -- about uh...you know, had we addressed all the problems. Uh...it turned out that there were still one or two small problems in the system, but it was able to -- it was able to handle the load. Because at Norman -- the Norman system didn't have just the one radar. They had information coming in from three different radars coming into the system and hitting the system all at once. We had to get all of that handled and posted and ready to be viewed within uh...I think our goal was to have everything done within a few seconds -- two or three seconds. So we were keeping statistics on it to see how it was functioning.

43:04 There were times where things got behind badly before we put our new software in. Anyway, uh...it performed really well. They had one. I think they had to restart the system one time. They had one reboot of one part of the system. But otherwise, it performed really, really well. And uh...of course that was a huge um...a huge test of the overall modernization in the overall system. Um...the forecasters there, I think in one case had issued a tornado warnings about an hour in advance of the tornado striking the -- striking the town. So that was they were super cell based systems. They had long lives. They were able to get out and for, you know, follow them very well with the radar on the system and issue the warnings. Uh...we had just really good results -- good very excellent reports.

And they actually Dennis McCarthy who was the MIC [Meteorologist In Charge] at the time, had was called to testify in front of Congress. And he said basically, the two things that really made -- made everything work well that day were the new radar system and the AWIPS system. Where they were able to look. They were able to have the radar data available at all the work stations, so they were able to use multiple work stations. And they even had one -- one of the work stations dedicated to uh...interacting with the spotter network. So they could keep spotters well informed and the emergency management community well informed. So it was -- it was really a great uh...kind of a great milestone for the overall system. I think it demonstrated hands down that the modernization was well worth the investment of time and -- and money that had gone into it.

Um...the emergency managers who had been there and lived through similar episodes said they estimated that the death toll would've been between four and five hundred for the kind of outbreak that they uh...had that day. And instead they only had forty-five deaths. So it was a real testament I think to -- to the -- to the value of what we had been able to accomplish through all that, through all those years.

45:40 Uh...okay to go on now. Uh...1999 we actually were had been putting on and received a gold medal Department of Commerce Gold Medal Award for the work that had gone on. And of course this involved a lot of people. Not just us here, but the people in back of the Weather Service headquarters. And I will say, and I want this to be part of the oral record as well that the PR -- the group at PRC after the decision was made in 1996. They -- you know, they swallowed hard. They were very disappointed. But they really uh...were great to work with. Um...they came aboard. We

had some meetings, and you know what we worked very, very well with them from that point at that point. Um...they were in charge of getting the system fielded and putting all the communications in place. And they did a great job. Uh...so I want -- I want to acknowledge that they played an important role and were very instrumental in -- in the success of the AWIPS program.

46:52 Uh...1999 was the uh...Kelly Report [independent review led by BG Jack Kelly, USAF Retired]. Uh...they said we need to get this system out and we need to get this done and that done. And there was a set of capabilities that were referred to as the deferred capabilities that hadn't been done. And that was really where the forecasters were gonna be doing business very differently than they had done in the past. Where they were going to create a digital rendition of the forecast data as opposed to just looking at all the information and then typing out products at infinitum. So that came out as part of the 1999. And they told Congress it's gonna take an additional investment here of I think twenty-five million dollars to get this completed. And Congress was not very happy, but they said okay. Uh...go for it. Get it done. Be sure you you know, are doing it on the timeframe. And so that was the Kelly Report. And uh...of course politics had gone on as well.

So I think at some point, Joe Friday uh...left and Kelly came on as the head of the Weather Service. As we -- and we were working away with that. There was a lot of uh...internal pull back and forth between us and TDL with the ICWF system. We were trying to merge the two systems. And what was the best way to do it? And so on and so forth. So there was a lot of a big -- a big story so to speak behind the scenes story that was going on there as well.

48:34 Anyway, we -- we worked away with the software. And we finally um...were able to put in in place the GFE -- Graphical Forecast Editor. Oh, I'm not even sure what the -- what the year was when that really came -- came into full use. I want to say 2005, but I'm not sure. It may have been even a little earlier than that. Anyway, we took on a similar approach. We had a -- a group with the Weather Service looking at the requirements and what needed to happen. We set up a series of prototypes very rapidly iterating prototypes here. At that time it was FSL. Or maybe we -- yeah, I think it was FSL. And um...with very um...intense interaction with the field we were able to iterate on the system and get it -- get it out and working so that it was adequate to support what needed to happen. So that was -- it might've been 2004 when we had the first early versions of that running.

Uh...so that continued to develop and progress. And we ended up using a -- instead of using the TDL system to generate the products; we ended up working with the prototype system that had been developed in some of the forecast offices. And we were able to parlay that into uh...into a system that would generate all the products and have all the capabilities that um...that were needed. And eventually we had to -- had to broaden and expand that to include all the watches and warnings. So we had another kind of, I don't know how to describe that. Another, it wasn't a fire drill but it was a very intense period of development to get to -- to get all the watch and warning capability into this new digitized system. Uh...I don't remember the dates on that. It might've been 2007 when we had

all that finally up and running. Something like that. But those were some of the significant points in '99. And then getting the GFE into the system in 2003 or 2004. And then bringing in the watch and warning capability in I think it was 2007 when that was finally. And it's still being you know, tweaked and enhanced even as we speak. But basically they -- they had all the -- all the system in there.

51:35 Now having said that, I will say that um...because we were under the gun when we started in '94 we had to do things very quickly. And so if we had had more time, I think we would've -- we would've done things a little differently. 'Cause we ended up with the GFE being kind of a separate piece of software in the system. So you -- you spend your time looking uh...at most of the meteorological data. And then you go into the GFE or you go on into the hydro portion of it. I forget the name of those applications now, the hydro apps. Uh...so you really have some disparate software that are being used currently in the field. And uh...one of the -- one of the jobs that we're hoping will get done is merging all of those capabilities at least for the warning program. Because right now in the warning program if you're issuing severe thunderstorm or other warning, tornado, flash flood; you use the AWIPS system. You use the Warn Gen [Warning Generation] application. If you're doing a longer-term warning, um...a winter storm and all of that sort of thing uh...then you're gonna be using the GFE. Uh...in the cast of the severe thunderstorm, if you have a watch out then you're gonna be using the GFE to do the watch. And then you issue the warnings over on the AWIPS side. And if -- if it's a hydrologic episode, then you're gonna be using the -- the hydro applications. So it's not the best world right now with three different applications for… to support the warning mission. So that's work that's going on to try to bring those all together. Well, let's see. What else? I talked for about an hour.

Barry Reichenbaugh: Yeah. You're running out of voice probably. But well, you know I think you've covered a lot of ground. Uh...I know we have for listeners we've got a lot of acronyms in there. I'm gonna try and uh...throughout these uh...list acronyms as sort of a guide to go along for people who don't have that familiarity. How about summing things up? Is there -- there aren't too many comparable systems of this size and uh...that have been developed successfully.

Carl Bullock: Well, I guess I would say again, the McIDAS System has been very successful. And the McIDAS System is much more capable than the AWIPS system. The real difference in our system is that in the case of our system, we recognize that the forecasters have a -- have a time critical function that has to be performed. And from the experience that we had going back to the early 1980s of working with forecasters, seeing how they operate, seeing what they need; we tried -- we have tried very hard. And I think have been largely successful in taking away a lot of the mundane kinds of decisions that they might need to make. And making assumptions, correct assumption for the most part about what the forecasters want. So that instead of for example, instead of seeing a satellite when you want to view a satellite image. A traditional system will ask you find how many -- how many frames do you want and what's the time frame. So you have to tell

the system what all those things are. You don't have that kind of time when you're in a forecast office. You want to just see the satellite. So what -- what are we assuming? We assume that when they choose this satellite product, that they're gonna by default they're gonna make that into a loop. And whatever has been uh...defaulted at the moment. And we're gonna bring that loop in. And we're gonna start that -- start that animation going for them. So they don't have to -- they don't have to decide what time they want to, what are the time intervals and specific time values of the images. We -- we handle all that behind the scenes. That's one of the things that makes our system very different.

56:11 The other thing that makes it really different is that our system tries to be, for lack of a better word I'm gonna say our system tries to treat all of the sources equally as being equally important. Um...so we um...if you're just looking at satellite data, you're gonna do things a little bit differently. If you're just looking at radar data, you're gonna do things a little differently. And -- and those things make sense in the context of those data -- of those data sets. When you're having to look at everything, you need to put everything on an equal footing. So that you can use satellite data with the radar data with all the data, with model data, with observations. Everything can be used in an integrated or uh...synergistic manner in our system. So that's another very important aspect of our system. Those things flow in very easily, very readily into the system. Uh...again the real thought behind our system is we don't want forecasters to have to think about how to do something. We want them to simply do it because they have other things they need to be thinking about. And that's the -- that's the approach that we took from the get go in the PROFS system. And I think we've been very successful. Not a hundred percent, you know. There are some things that we've overlooked, that we've left out that other systems.

57:45 And I will say that other systems do things that our system does not. They're more powerful. They're more flexible. Uh...they can do things that our system does not. But we have tried, and I think hit the mark pretty well, to hit the core set of requirements. The other things are nice to have. We can add them. But we've hit the core set of requirements that forecasters need to do their job, to do it in a time critical, uh...time constrained fashion.

Barry Reichenbaugh: Anything else you'd like to add?

Carl Bullock: It's been uh...wonderful working in NOAA. I really have enjoyed it. I enjoyed the people I worked with. And enjoyed working with the technology and seeing that. I mean, the changes are just almost unbelievable from the time I started this as a meteorologist intern until I retired. One of the uh...so it's been very satisfying on -- on those two aspects. I think at the time we put our system in place in 1999, was arguably the best system in the world for what it -- for what it did. The GFE is still rather unique. That set of software that allows the forecaster to create a digital representation um...of the forecast data is still relatively unique. And it's been adopted by a number of countries internationally now. So that uh...that's been very gratifying. I will say that we in one of our -- in AWIPS Build 5 operational Build 5.

We had some problems that were cropping up uh...that stemmed from a number of sources. And uh...I'll maybe make this my final comment. We went down to one of the forecast offices in Jackson, Mississippi. We went down there because they were anticipating a severe weather outbreak. And so they had -- they had a new -- this new build. And we wanted to see what the problem was. Well, it turned out that they most of the problem was a local application that they put on. So once we'd taken that off and we made a few other adjustments, the system worked great. It worked just the way it should. But I had the chance to watch forecasters. And they had three forecasters issuing warnings at one point in time. I watched them push the darn system as hard as they could. And there were times that I just had to hold my breath, 'cause I wasn't sure it was gonna be up to the demands they were -- they were making of it. But it worked uh...just extremely well. It was just so gratifying to see uh...your work used the way that it had been envisioned. Actually, they pushed it way beyond anything that we had imagined in terms of the usage. But it stood up well. And uh...it supported them well in issuing their warnings. I think they issued something like seventy-five warnings --tornado and severe thunderstorm warnings that night. Uh...and it was great. It was great to see the system operate everything running out -- running the way it should. So very satisfying to see your work being used that way.

1:01:11 One other kind of post script thought that -- that comes to mind. Uh...I remember early in my career looking at some of what I consider to be the golden ages or golden times of meteorology. Uh...there's some times at University of Chicago, and at the University of Washington. And there are other examples where this could be -- could be cited. And it became clear to me in looking at the history of those, that the personalities involved were essential, were key to making those things happen. And -- and I'm sure many. I've talked to many people and they will agree with me that uh...we had a -- we had a happy confluence of key people uh...to make this happen. Hallgren, who really knew how to -- how to work with Congress and how to -- how to sell programs that needed to be done. Uh...Doug Sargeant and Lou Boezi who were both involved with systems development and knew what needed to happen there, and how -- how they needed to be supported and kind of shepherded along through the process. Uh...Mary Glackin and Fred Zbar who were in charge of the requirements, and who really were very uh...very open and worked very hard with the -- with the teams to uh...bring the requirements into being. So that we had something to work with and to start from. So we had good support all the way up the chain, all the way to the director's office and all the way down to the PROFS program. We were all pretty much on the same page. Uh...we would go back to Washington two, three, four times a year. And what was then known as the Troika meeting where we had a chance to describe our work, and we got uh...we got direction from the highest levels of the Weather Service if they liked what we were doing. They told us if they didn't. They would give us constructive criticism about the change in direction and that sort of things. So it was um...it was really I'd say a happy confluence of having the right group of people there, uh...the right kind of support, and -- and really the right, even the right mechanisms of meeting and interacting together uh...to help us through. Because there were a lot of -- there were a lot of decisions and

tough times. And a lot of political oversight, and political storms and wars that had to be fought. And those are the kinds of things that you don't -- you won't see just looking at the program and looking at the facts uh...as they kind of lay out on a sheet of paper. But they are very important. And I wanted to acknowledge those individuals that were involved. They were very excellent to work with. Ward Seguin later on taking over for Mary was great to work with. Uh...George Smith and others, so we had really a good group of people. TDL, Bob Glahn, really, and Dave Ruth, really a good group of people to work with. And I think in the -- in the end, that's something that may get lost. But it needs to be pointed out that having the right people there uh...really makes a huge difference.