JULIANA BLACKWELL: Admiral John Bossler former director of the Coast and Geodetic Survey who led the transition from NAD 27 to NAD 83. Admiral.

MR. DOYLE; Before John gets started, we have a minor technical difficulty with our projector. Now the people on line can see it but we just can't see it in here yet. It's going to take us a few minute so John, if you would just when you need to, when if you want to just say next slide, then, they can change, people on-line can see it and we will get it as soon as it comes up.

ADMIRAL BOSSLER: I can do the soft shoe.

MR. DOYLE: A couple of minutes

ADMIRAL BOSSLER: Well, it is a great pleasure to be back in my old stomping grounds here and talk to you and the greatest pleasure was to see a lot of NGS people I thought would be long gone and they weren't.

But I would like to know how many people in the audience are over 73? I win again. I see one hand, maybe I lose. Well, the reason I'm here is that Dru Smith called me and said, we'd like to hear you talk about the problems that you faced when beginning the 83 datum, and subsequently, the NGVD 88. So I thought about that and I put a list of projects -- or problems together that I have shown to you or will show to you.
I don't claim they're the biggest problems that we had, or the most interesting but I put down what I first thought of because usually, sometimes that's a good way to catch the best problems. Are we ready yet Dave? Okay, first slide: Still not ready?
You need to turn those lights up a little brighter because I still have pupils in my eyes. Another couple of watts, I won't be able to see anybody in the audience, which will be good.

First slide: Do I press something?

MR. DOYLE: No, you don't.

ADMIRAL BOSSLER: Well, what kind of story can I tell? I once went to my old -- I went to the University of Pittsburgh as a bachelor's candidate in Civil Engineering and they asked me to speak there at some point in time. And I took a videotape with me. In those days, we had videotape. And I went to show the tape and I had my talk all arranged but I didn't have much time to prepare and so the video was it. Whatever I was going to say was on that video. And it didn't work. And it never did work. So I was in the same position that I am now. It's a little worse because I hoped this does work at some point in time.

Well, how about we reverse this. Why don't I ask some of my old employees some questions? That ought to get your attention. Renee, where is Renee? Oh, She's back there.

Well, here's Richard Snay. How do you think Juliana's doing so far? Don't laugh, you may be next.

Louie Lapine, when will you gonna retire from South Carolina?

LEW LAPINE: (low audio) After we see what this new adjustment will do

ADMIRAL BOSSLER: Going to change all your coordinates.

LEW LAPINE: (low audio) No because I said the coordinate system would never change if I moved to South Carolina

ADMIRAL BOSSLER: Will they show it or do I have to say again, first slide.

Right now, they can see it -- will I be able to see it on the screen here? I have a flash drive here. That's what they are trying to do. I think they got one of those. I think it's a projector issue.

I could tell some jokes but ah, one thing that I could do is to skip to the next to the last slide. It's an interesting story about a consulting task that I took on and I tell it because it shows you how eclectic the users of geodetic data can be and it'll be good way to fill in the time. By the way, this isn't taking off my 20 minutes is it? Because I'm already done.

Okay, one day the public defender from the State of Washington called and said I have to defend some smugglers that were caught crossing the Canadian border with a bunch of dope on them and I don't think they were in the United States when they were caught. I think they were 800 feet away from the United States because that's what GPS says. So I said, well, the first thing I would say to you is the monuments have first order of call in a surveying discussion or fight or argument. And he said, no, you read the statutes of the State of Washington and see whether you believe that after you read them. And I read them and it did put up a compelling case for the fact that the true 49th parallel would have been the border, not where the monument was but still, I knew the law well enough to question that but I took the job and I spent maybe a week, cost them a lot of money, studying how we determined the border, the 49th parallel in 1850, which is about the time they did a lot of that work, especially out west. And I could not find any error in the zenith telescope work that exceeded about a second of arc. And I tried. And they did everything as good as they could and they did in fact come up with the correct position as far as I could tell plus or minus say a second in terms of one standard deviation. So, the Court case was coming up and they said you got to come to Bellingham, Washington and help the public defender. And I said I don't know what's wrong here. I can't figure this out. But I should have known that something and it dawned on me before it was too late, I was sitting in the anti-room of the courtroom and it occurred to me, hey, these are all astronomic positions and GPS doesn't get that. So maybe I can find out what the deflection is here. And I had a computer in that anti-room; this is a long time ago and so I got on your website, the NGS website and I put

the coordinates in for this particular place that they got caught. And sure enough, the deflection there in terms of meters or feet was 800 feet. And then, it dawned on me, these guys had positioned the 49th parallel in terms of astronomic latitude, not geodetic latitude and in fact, when I went back and did further research, the concept of the deflection of the vertical really hadn't come about. They were starting to understand that the plumb bob didn't hang down the way they thought it would and so there is some phenomenon here and pretty soon we had all the Stokes equations and so forth. But that particular time I was very, very proud of NGS for providing that data. And then, I had the task of course of trying to convince or explain to the Court what the deflection of the vertical was and how that mattered. And that was even more challenging. In the end, the smugglers got caught or they got sentenced again found guilty as they were. The smugglers had very unique ways of bringing this dope into the country, the women, there were I think two men and two women captured. The women cut the edges of their bras at the seam and stuffed dope into that pocket. They were killing two birds with one stone there. And the men put dope down in the middle of a cane but what they forgot about was or maybe didn't know, I don't know, in those days we had already had dogs that could sniff out dope. And that's the way they caught them, otherwise, there was no chance of ever catching them. They were very slick but they got them because the dogs smelled the dope. Anyways, I bet you that none of you have ever thought about using the deflection of a vertical or astronomic positions in such a way. So beware of your users out there. There are many unique and funny ones that you will never find in the Leveson Report, I will guarantee.

Are we ready now? No.

DAVE DOYLE: They can see it on line?

Well, okay, yeah, that works.

My next slide that you can't see is I'm gonna talk about these things, financial problems, technical problems, user problems, and interesting user examples. And we are not going to talk about that interesting user example because I already did. The last slide is called Bossler on redefinitions. Okay.

Here are the financial problems; the overall budget for the 83 was definitely inadequate. And somebody – hey there we go! Oh, go another one. Go another one. Great. Somebody and I don't really remember who it was, it was either Robert White who was the Director or Administrator of NOAA at that time or Admiral Allen Powell who was the Director of C&GS, but somebody suggested that because we were just starting and there was some interest in this redefinition problem that I brief, an associate administer called Jack Townsend and later, briefed Tony Calio who became the Administrator of NOAA. Now, this was one of the best things that happened to us. Townsend had in his slush fund, about the same amount of money, Juliana, as we and had for the budget of the NAD 83. So I used to go there and ask for money and generally, speaking, every time we went, we got a couple of hundred thousand dollars. And a couple of hundred thousand dollars in NGS circa 1978 say was a lot of money. And that did a lot of good.

Townsend did get interested. I spent alot of time on that first briefing I remember, sweating and trying to make it interesting, tell them how much science was in there and how many users we had. And he asked for a briefing every quarter. And that was absolutely the best thing that ever happened to us for this project I promise you that. There were a lot of costs overruns mostly in data conversion, some in software for sure. I would guess that by the end of the project, 50 percent of our work was done by contract and the description keying was one of the biggest of those. And the director of the data center, a fellow by the name of John Spencer, at that time, knew some prison officials. And he said, I think it would be a good idea if we tried to get convicts to key the data, the descriptions.

And so, we started that and the first few weeks were a disaster. These guys wanted to get out of their cell and screw around instead of doing this right. But we figured out a way to catch them. We double punched these data, in other words, we punched them one and punched them twice and compared them. And we found the people who really wanted to learn something and get a job later using that technique and those skills. And we kept them and we canned the guys that really didn't care about keying up descriptions. That was great. We did finish that task as far as I know.

Next slide, technical problems.

How come you don't go when I go? There you are.

The first problem that I can remember was very interesting. We decided to do this simultaneously, solve a million equations and a million unknowns. This was not heard of in those days and in fact, at some point in time, an editor from Science Magazine came and wrote a great good article about solving a million equations with a million unknowns simultaneously. But I was worried that the last latitude and longitude or, X Y, Z, whatever we were using at the end of this reduction would be noise and not a latitude or longitude. And this is because in those days, even with double precision, it was a scary thing to do. So I asked a friend of mine, his name was Peter Meissl, a geodesist from Gratz, Austria, worked for Helmut Moritz and others, to come over for a year and work on this problem. He did that and wrote a seminal report, what our best publication was, called a professional paper that showed that in double precision, we had good data at the end of this reduction. Sadly, Peter Meissl one of our best geodesist and his son, both died in a climbing accident in Austria a few years later. That kicked off by the way, the visiting scientist program that some of you know and remember.

We also had a space problem. These matrices were sparse and so we had a lot of memory used up and it didn't need to be used up. At that time, it was very popular and vogue to try to compact these equations. Dwayne Brown did some major work and some vanguard work in that regard. But we had just required a young whipper snapper fresh out of college who study topology and stuff like that. And so we said, Richard, solve this problem and he did. And that’s a famous algorithm, famous to me any way called the Bankers used here and there. And I talked with Richard yesterday I said, now since you've retired, you should solve the general problem of compacting equations

which to my knowledge has never been solved. In other words, this was a specific application and he got probably, optimal results here but let's get it for any set of spares equations. That will give him something to do any way. A problem that I think still exist especially after reading Dru's very good paper on the need for some kind of improvement here in the network is the weighting of observations. When I took the job of project manager, I remember taking so many astro observations, I was on astro teams and realizing that the standard error that we assigned to azimuth and latitude and longitude was not correct. It was way too good. And so I asked Bill Carter and Jim Petty and some people in the astronomy division to do a between nights, not a within nights analysis of the variance and sure enough, we changed from something like .75 I think in azimuth to 1.5. And it worked, I mean the standard error of unit weight became more like one and everything showed that this was the right thing to do. I think this is certainly true in every aspect of our observations. The leveling data, some constant times the root of the distance around the loop is not a measure of accuracy by any stretch of the imagination. And you have to be wary of this and you have do as good as you can to get the right weight.

Next slide.

We also were of course going to iterate the set of equations and Allen Pope, a person who worked in NGS at that time had written a paper called pitfalls in doing least square adjustments or something like that showed where you needed to be careful when you're expanding the Taylor Series in a nonlinear situation. And I'll betcha that half of this audience doesn't realize that if you want to get, say the orthogonal regression line and you measured both X and Y, to do that, you have to iterate that nonlinear equation. And if you follow Allen's correct and obvious now, A posteriori obvious procedure, you will get the orthogonal regression line. You don't have to do what Deming did and many others write the equation of the line that minimizes the sum of squares of the residuals from the point to the line. You can get it by Y plus B or X equals KY plus C, if you iterate it properly. And we did put that into the reduction process. I know I went over with John Eisner myself and he convinced me that yes, yes John, we have this correct. And he was right.

The geoid was pretty bad when we started and we have an objective of one second of arc in the deflection of the vertical across the United States even in the pathologically bad areas like the Rockies. I don't know how close we came to achieving that but, I think pretty close, maybe not in those bad areas or tenuous areas, but we did have a second standard error most of the places and that team was made up of Bill Strange and Tom Soler who is still here, Rudy Fury and lastly, Clyde Goad who sort of brought in the long wave length data from the satellite systems.

The data management was a major problem because this thing was enormous. I woke up one night thinking what if the Rockwall Building would catch on fire. And I really was worried about that and I sort of woke up screaming. And the next day, I went to see Gary Young and Libby Wade and they said it's under our beds at home. And it was.

The processes there were very complicated too. I don't know them all but I know that they were needing to be organized and the people that did that were Libby and Gary and Marilyn Vorhauer and others.

User problems, next slide.

This is going slower because of this slick process that we have here. Actually I was going to be very complimentary, but I think now about the new technology Dru, good job. My God I could have view-graphs. Well, the surveyors sure didn't understand in 1977, say what we were doing or why we were doing it. Their particular little area if it wasn't distorted was good enough. And so we had user meetings at NGS, went to all the ACSM conferences, all the ASRPS conferences. People like Charlie Challstrom and Dave and in those days and I went to many and tried to explain what we were doing. And in the end, they really loved what we did of course, and it took a long time. The other Feds that were our partners like Joe said, weren't too good of a partner in those days either. The USGS was very resistant of the datum and understandably so. I remember many battles that I had over at the National Mapping Division. But once we were able to tell them we could compute the NAD 83 coordinates close enough, that there would not be a measurable error in the one to 24,000 series, and we could do that now, say circa '80, then, they became more in favor of the adjustment and got on board. The same was true of C&GS, the nautical charting people in particular were very reticent to do this, fortunately, I was the director of C&GS about that time so Admiral Bossler told them, let's just make up a schedule and that's the way it was. I don't –

Next slide –

I don't really have inside knowledge to much of an extent in the NAVD 88 and my colleague and next speaker will be able to tell you more than I can. But I do know that many of the problems that we attacked in the horizontal adjustments so to speak, were solved and helpful to those working on the NAVD 88. There was still a money problem, even more so I think than was in the 83 because it had a bona fide budget and I don't know whether we ever did in NAVD 88. But we had some kind of a budget but Jack Townsend came to the fore again and so did C&GS. And in fact, I made lifetime enemies in C&GS for taking their money, the aeronautical charting people in those days were rich. Frank Maloney had a lot of money and I knew it. I was the head of NGS. And so I want to Admiral Powell and I said he doesn't know what do with that money, give it to me and he did. And when Frank went downtown, here a few years ago, he remembered that and I think you guys got punished probably, Louie and Charlie and Dave all felt his ire from me taking the money. There was still technical problems, lots of them, weighting problems and the origin problems. Where should we put the origin, well, Chuck Whalen, Dave Zilkoski, Gary Young and others solved that problem. And you know where we are with it. I talked about this so why don't we go to the very last slide.

Next slide.

There we go.

Well, these are the conclusions that I came to after reading Dru's paper and several reports. I think this Leveson Report is a really good document that you can make some hay with and I would exploit it to the maximum extent possible. I conclude these things for right or wrong that the vertical datum is certainly at this point, the most important. And I think the strategy of using GPS with a very accurate geoid is super. And I would predict that in a decade, anything less or more than one kilometer in length will be done in this fashion. Leveling for that kind of distance will be no more. I do believe that leveling to see if your foundation is going to be level will be going on for longer than most of you will have a career here. So you have to watch but, the idea -- your idea called GRAV-D is superb and I love it. This has been said already by Juliana but I want to say it again and I believe you all who are doing work and practice like Dr. Lapine would agree that user constancy is really important. People don't like to have – you know surveyors hate what they call porcupine points which means that there are four or five rods, sticks or monuments showing where the corner is. Users don't like porcupine data either. And so, whatever you do when you change a coordinate, think about keeping that coordinate as long as you can. I'm not so keen any more on accuracy, especially horizontal kinds of accuracy. But of course, that's what the surveyor said to me when I was trying to do the NAD 83 so I had to be careful here. There's lessons to be learned because you have to watch them but I think especially absolute positioning is only important to a very small percentage of the users. And lastly, your new paradigm for interrogating the CORS stations, and computing velocities and positions 24/7, 365, and being able to pass that to the users is the neatest thing that I have seen in my career in geodetic science. I will leave you with that. Thank you.

I'm not sure how to turn off -- I want my flash drive.

MR. DOYLE: I greatly appreciate John's reflection on what we went through to create the NAD 83. John gave a wonderful story there at the end about the use of positioning and I think many of us have this hindsight. I would just like to reflect on that myself. I get a lot of strange questions from the public. And one of my first functions at the National Geodetic Survey when I came in the office off of a field part was in our information center. Back in those days people actually called up and asked for the data. It was all on paper and in those days, I can remember that when my phone rang, there was only one of two people on the other end of the phone, there was either a surveyor or it was my wife. That was it. Nobody else ever called for this data. John pointed out we see so many changes now. Not long ago, a couple of months ago, I had a request from a research scientists at -- in Oklahoma who identified himself right off as the lead goat researcher in Oklahoma. I wasn't quite sure what that meant, not sure I wanted to know. But he was curious as to the location of all these high accuracy GPS stations so that he could evaluate these collars that he puts on goats so he can -- I had his picture of him pulling this goat over to a survey monument standing there to get his position. But it shows the vast change that we have seen in the last few years in the number of users and their demands.

Now, I would like to introduce Dave Zilkoski, the former director of the National Geodetic Survey, who was the lead on the North American Vertical Datum of 1988.