MMS OFFSHORE GULF OF MEXICO

ORAL HISTORY PROJECT

Interviewee: SAM EVANS

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Interviewers: Tyler Priest
Dr. Joseph Pratt

Side A

TP: Mr. Evans, let us begin with your personal background and how you came in to this industry.

SE: I was introduced to the geophysical industry as a result of a job offer from Geophysical Service, Incorporated, GSI. This was in 1951. I had just finished school at Hendricks College in Conway, Arkansas, where my major was math and physics. I commenced my background there as an observer/trainee, which was literally that; it was training to learn how to record seismic data.

TP: Where was the GSI office?

SE: GSI was in Dallas at that time. And I will digress a little bit … at that time, GSI was a private organization. And down the hall from where the GSI's office was there was a small group, a sealed off, secret group, which was called General Instruments. Probably about six or eight months after I started work, General Instruments became Texas Instruments, and Texas Instruments then ran GSI. Many of the founders of TI were also the founders of GSI. But at any rate, TI and GSI made a good combination for development of instruments and equipment and that sort of thing.

In those days, the seismic contractors' stock and trade were basically their instruments. These were vacuum tube devices that had unique features, company by company, and nearly every company built their own and used their own. And clients would hire them on the strength of quality of their instrumentation; not so much other equipment, but just instruments. That changed, of course, in the 1960s and 1970s as the commercialization of the instrument making boiled down to two or three suppliers.

I was initially assigned to land crews in Idaho, California, Nevada, and west Texas. In 1952, I was moved from a land crew in east Texas to Morgan City, Louis That was, I believe, August of 1952. And there was just kind of a growth in progress of offshore seismic crews in Morgan City. Two or three companies were doing work out of Galveston in the Texas offshore at that time, but Morgan City seemed to be the main operations. There were company crews run by Magnolia which is now Mobil. Shell had the company crew there. Pure Oil Company had a contract crew. And then Union Producing, which later became Pennzoil, was operating the crew that I was on. Other companies there working included Kerr McGee, Phillips, and Forrest later came in and had some operations. But mostly those were all operating there.

All this work was being done out of Wooden Hole Craft. The crafts, for the most part, were world war II surplus, rescue vessels - 105 feet long . . .

TP: They had moved beyond the shrimp boats?

SE: Yes. They had moved beyond the shrimp boats a la the Thunder and the Bay, the movie, which I am sure you have seen. Incidentally, that movie was Filmed in Morgan City and that was still the talk of the town when we moved there. They had the world premier there. But, the techniques were all pretty much the same: three boats. One boat would carry the recording equipment and the streamers, the cables; not streamers, but the bottom drag cables. Another boat was used to carry the explosives the dynamite, and to serve as the shooting boat. The third boat was a supply boat which would run back and forth from the work area to the dock to get more dynamite, to bring in the data, and to change people and that sort of thing.

In those days, operations were strictly from daylight to dark. The reason for that was that surveying was done by radio positioning devices. There was Raydist and Lorac. The work was too far out to use direct shoreline type surveying, so the work day and the amount of production you could do was strictly controlled by the number of hours that you could receive credible signals. So, you had a limited work day. It is kind of interesting. . . the surveying was a very critical part in the early days; not so much the geophysical work but in some of the early wells, particularly drilled by Magnolia, resulted in some dramatically misplaced wells.

The story then was that Magnolia had drilled 13 wells and were ready . . . I am sorry, they had drilled 12. The 13th well was to be drilled, and if that was not successful they were going to forget about the offshore because it had been so miserable.

TP: About what year was that?

SE: That would have been in 1951, mid 1951.

TP: So the Tidelands controversy was still raging, but was this in state waters?

SE: This was in state waters, yes. The old Texaco block, which ran down through southwest Marsh Isle and way out, that still was in existence. We could not get on that. But some of the real inland blocks, Louisiana land blocks . . .. the story was that Magnolia was spurring the driving pile for their platform and they actually encountered the salt, the top of the salt dome, with the piling. And they were supposed to be off by quite some distance, so they suspended everything. They did a lot of resurveying. At that point in time, they had done most of their surveying by starting on shore and carrying long traverses out and then using long chaining lines to establish points. But the whole survey was off. And once they established that, then they started drill some of the domes that they had been intending to drilling and had fantastic success early on. So that really kind of started the whole thrust of everything out there.

TP: Once they had the survey and the data . . .

SE: Once they knew where it was … well, once they thought they knew where it was! It was still a long way to go, though, but . . .

TP: But the early wells that were misplaced were based on not a lot of seismic surveying?

SE: Yes, I think they had a lot of seismic surveying, but it was misplaced too. And I can probably give you some names of some Magnolia people who were involved in some of those in those days if that is of interest to you.

TP: Yes, it would be.

SE: Magnolia, Phillips, Shell, and one or two other . . . Kerr McGee was very active at that point in time . . . they all had big camps set up and their workers or people lived on those camps. They did all their work there. They had big docks and big operations bases that they were doing in their drilling. Then, after a few discoveries in the state of Louisiana, the federal government announced their plans for sales. So most of the companies were working out into beyond state waters; all the way out to, I think 60 feet. No, it was actually 120 feet, was how far we were going out.

TP: This was in 1952-1953?

SE: Yes. We would take lines out to 120 feet , but no one really figured that they would be drilling wells out there. And it seemed like every time we would stop, 30 feet, 60 feet, 120, you would start coming up on more features as you moved out. And so, there was no stopping, really. But the sales were taking place inland from those boundaries and that is where we did all of our work.

In those days, the recording systems were 24 channel.

The cables in most all of the crews were identical in this regard - 24 channels. The cables were deployed on the bottom. We used chains and other type weights to hold them on the bottom. The detectors were actually land geophones that were suspended. They were buoyed up with small air bottles, oxygen bottles that held them up off of the ground, off the floor three or four feet. After the shot was taken, the recording boat, which was still, would pull up 1,320 feet, let the cable settle back in, and get quiet. The shooting boat would be off to the side waiting. The observer would tell the shooting boat to move in and he would move in on a buoy in the center of this 1,320 foot spread, and there would be a buoy there and he would move in fairly close to that, dump his 30 or 50 pound charge into the water, and then play out a lead for detonating that. And when he was far enough out . . . incidentally, the charge would be floated with a balloon or a turkey bag, plastic bag or something, to keep it suspended at 3 or 4 feet. And he would tell the observer, he would give a command, "It's in the water." And then, the observer would shoot the shot. He would detonate it by radio from the recording boat, record it for five or six seconds, and then the whole process would be repeated again. He would move up 1,320, redo it, and that would go on all day long or as long as they had suitable radio signals for the positioning.

I had witnessed Magnolia, and never Shell, but the western crews and the pure crew which was an old company named Geotex. And everybody did it the same way; it was identical the way they did it. You would get usable and believable data, maybe two seconds, which would equate to maybe 6,000 or 8,000 feet at the most. But we would always do more interpretation deeper. Most of the targets, however, at that point in time, were up in the 6,000 to 8,000 foot range. Of course, you would see the domes, but no definition of the domes.

Nothing was done with the data except to take the raw data. The data were recorded on just paper records, no magnetic recording; nothing that you could use for doing any sort of signal processing. And those records would be washed and hung to dry and sorted and labeled. And all this was by hand. And then it was given to a seismologist who would actually pick the records, go through record to record, and do the correlation. Those picks, as it were, would be carried to a piece of graft paper, a great big, long cross-section paper. Then, the seismologist would sit down and connect those points in time and give it a grade. And then a mapping seismologist would take over from that and draw that geologic inference was to be drawn from that. so that was very crude . . .

TP: The seismologist would be appointed by Geoservices?

SE: Yes, everything was done by the contractor; all the way through the interpretation.

TP: But did the oil companies have their own seismologists?

SE: Not on the crews. They would often have what we called a bird dog. A lot of times, they would bring a new geologist in and he would literally train on that. And he would oversee these things and coordinate some of the things like where the lines were going to the new program that would be required and that sort of thing. But, for the most part, you just shot everything on a fixed grid. But after interpretations, you would go in and do detail lines, split the grids, and that sort of thing, and the client would have a lot of say in that.

Every Friday we would generate contour maps and send those in and that would go on. And, of course, as lease sales came up, it was just a frantic press day in and day out, 24 hours, getting that data ready for the lease sale.

In those days, the contractors did everything. Here again, it was their people and their techniques that were their stock and trade.

TP: Who were some of the others besides GSI and Western?

SE: It was GSI, Western. There was a company called Geotech, who are no longer there. There was Seismic Engineering in later years. Most of the major oil companies had their own crews. They owned their boats, they owned their equipment, and they did their own operations. And there in Morgan City, they had large interpretive computer no acute distress interpretive staff just 1 the contractors did.

TP: So, the contractors were mainly servicing the smaller companies?

SE: The union producings and the pure, and those companies, yes.

TP: I remember Shell had guys working on their own instruments. I know that they developed their own instruments.

SE: Yes, Shell built and designed

TP: A guy named Murton. Does that name sound familiar?

SE: I remember those names, but I do not know them, no. Shell was very secretive about everything. At that time, there was a lot of camaraderie between the different offices and the people on different crews. We would all see each other in the bar and the coffee shop and that sort of thing. But Shell was not allowed to come to coffee with us! They had to be very careful about who they were seen with and who they talked to. But we got to fraternize with them anyway.

It was kind of funny . . . I mentioned the paper records. These records would supposedly be six seconds long. Well, sometimes they would be seven, eight, and so forth, so you would have to trim that end off. And most of the people would trim those things and put them in a bag and burn them or throw them away. There was just a of paper out there, meaningless by themselves. But Shell saved every piece of paper. And once a week, someone from New Orleans would come out and gather those up and take them in to be destroyed in an office there. I do not know whether they shredded them or what! They were not going to let anyone see anything that went on. A friend of mine actually had the job of transmitting the papers to be destroyed.

TP: Well, I know they had a reputation of secrecy.

SE: Those approaches and techniques went on for quite some time. In late 1953 . . .

TP: Is this still a three-boat operation you are talking about?

SE: Yes.

TP: And you spent a lot of time on the boats?

SE: Not a lot of time. Having been an observer, having learned to do that, then I would go out and help sometimes, and we would visit the crew. someone would go out there to kind of provide some sort of oversight.

TP: But your position was seismologist?

SE: I was a seismologist. My job was organizing and picking the records and getting them to the interpreters, to the people who actually made the maps.

In mid to late 1953, GSI bought a company that was working in Venezuela, and I do not remember the name of the company. Maybe the name of the company will come me. But this company had developed two things: I think the most outstanding thing was a receiver, a detector which was not a velocity moving coil, land type of geofoam, but it was indeed a pressure recording device. It was piezoelectric crystal. The inventor of this was a guy named Pavey. They could actually move the cable through the water, continuous tow, and record. So there was no stopping, backing down. But theyhadalso developed a single boat operation. They were the f people to do a single boat operation. And they had been working in Lake Maracaibo. They used a technique which was called a yo-yo, in which they would, instead of stopping and letting the cable settle, they would reel out the cable so that it would stay in one place while the boat moved ahead. And then, when they got to a certain point, they would detonate the charge from the recording boat, from the only boat, by sliding a charge down a long line to the middle of the spread. And, at the end of this long line was a great big, huge copper conductor. Just a big old copper clad device there that fed a circuit to there and the other side went back through the water. So, as the charge was hooked to a connector, as it would slide over that copper, then there would be an electrical contact made and the charge would detonate. So they had the single boat that could go anywhere. It was a large boat. GSI bought that company from Pavey and took over that.

TP: The company wasn't named Pavey?

SE: No, the company's name . . . I will get the name for you. I know one of the fellows . . . there is a fellow named Tom Fulton who is still around and I will get the name of that company. He was with them at the time. They [GSI] moved that boat to the Bahamas for Calco, Chevron now, and they did extensive amounts of work in the Keys. I said the Bahamas - they actually moved and had an off set up in Key West. And that was really one of the first U.S. operations, a single boat operation.

They later changed this yo-yo to a constant tow and that came about, I am going to say, in about one year to 18 months after that. And that boat was called the Sonic. It went all over the world; mostly West Africa, Mediterranean, Europe, South America. I do not remember all of the places it worked, but it was a very popular boat because it was large, it could travel large distances, which some of these small, 105 foot, wooden hull boats, you would not want to take them some places.

TP: What type of vessel was the Sonic?

SE: It was an old LCI - landing craft infantry. It had very shallow draft, and it could go into very shallow waters; very unstably and not much fun to work on, I was told, but extremely durable and turning out financially very well for GSI.

TP: So, this was really the first single boat operation in Venezuela?

SE: Yes, that is kind of the history of the single boat operation. But, all the way up into the mid 1960s, the energy source stayed dynamite.

TP: Really?

SE: Yes, and I will tell you a little anecdote about what was kind of the demise of the dynamite. But, instrumentation did not change dramatically, the recording systems did not change dramatically, nor did the length of the cables change dramatically until the early 1960s when digital recording came into being. The first digital crew went to the field, I believe, in 1962, and my friend who I mentioned who went to Middlebury, was the party chief of that first crew.

TP: Was that for the 1962 lease sale, because I know that was a big lease sale.

SE: The 1962 lease sale did not have any data recorded digitally. Everything then . . the data were being recorded on magnetic tapes.

TP: When was the switch made to magnetic tape recording versus just the paper?

SE: I want to say 1956. 1955 or 1956. Probably more like 1956. And there were a number of devices at that point in time. GSI had a device called the Magnadisk which was a great big round disk. The most popular device was a Techno, which was actually an adaptation from a movie. It was the device used to record soundtracks for movies. That was the Techno. And then Shell was big with an old company called SIE. They built their instruments. Seismic Instrumentation Equipment.

Actually, magnetic recording posed a problem offshore in that you had to change these tapes. The tape drum would make a revolution and you would have to take that one off and put another one on which caused another revolution. And that caused kind of a slow down. Well, when the digital recording commenced, and I am sure Mike told you this, you just had one great big tape. It just went continuous, so you just started and stopped. So this simplified a lot of problems of data handling and materials handling on the boats. It was not until later that people realized that the beauty of digital recording, really besides the operational advantage, was that you then could do so many things to the data.

By then, people had realized that there were some very unique problems with working in water. You get all kinds of reverberations in the water and near the water bottom. You get sort of guided wave effect in certain areas from hard water bottoms. There was a lot of effort put into trying to get rid of those. And as that came along, digital methods became ideal for that -- to deconvolute the data. That was really one of the principal things. However, GSI devised a method, and I do not remember the year, in which they were able to dereverberate data from Lake Maracaibo, which is a classic problem area, parts of the lake. And that was kind of the forerunner of deconvolution, which is just kind of the standard today. That was done analog. It was not done digital.

TP: Can you explain, the best you can, what deconvolution

SE: Okay. Deconvolution. When you take a shot in the water or in the ground, or you use a vibrator - whatever you use - the signal prop goes downward. It is rebounded at the water bottom. It is rebounded from all the interfaces down. And as each one of these reflections progresses, there is an alteration to the original signal. Originally, you got a very crisp signal, a pulse as it were, which was maybe just a spike. When it bounces at the water bottom and goes through it loses certain energy and it gets modified. And as it propagates all the way down, it continues to be modified. And then it comes back and it gets the same corruption as it comes back. So, what you start off with is a nice, crisp wavelet that then turns into a great big elongated thing. In water, in particular, the signal gets trapped in the water layer and it goes back and forth, back and forth. And each time it hits the surface or the water bottom, it generates another reflection seismograph. So when you get through, you have got all of your original signal, plus all these multiples as it were superimposed on that.

TP: I see. So, it changes velocity as it goes . . .

SE: No, it does not change velocity, it just changes its phase and its physical characteristics. It gets elongated. I could draw you a picture. When it hits, say, the water bottom and passes through, and it gets another bounce tied to it, the signal convolved with what takes place at that boundary. So you have the convolution of that signal with this reflection interface and this interface and this interface and this. And then you get this over and over and over, so you deconvolve that. You reverse out that distortion.

Water, in particular, is terribly distorted, and some of the real modern techniques today address this by putting a receiver on the bottom and one up where they are towing or leaving receivers fixed. There is what they call the ocean bottom approaches now which far advanced to that, but early on you just lived with it; you just recognized it and you realized that you were getting all of these multiple reflections. Until digital capabilities came about, it was almost, well, not impossible . . . there were analog methods but they were very experimental, for the most part.

TP: Is this related to what is called true amplitude recovery?

SE: No. True amplitude recovery is . . . when I mentioned the instruments .. . but digital gave rise to that. When you shoot, you get a decay in the signal, the strength. Shallow reflections are strong. Real deep reflections are very weak. So you have a decay in the signal with time. By recording, to look at these, we apply volume control, as it were, a gain to the data, so that these strong signals are brought down to here and these real weak signals are brought up to there. That AGC - automatic gain control. With digital capabilities you can actually record what is being done to those data. You actually know how much you have brought this one down and how much you have brought this one up. So knowing that, you can take that gain out and what you are left with is true relative amplitude. So that this real weak thing down here compared to this strong thing up here/shallow, you can actually look at it in that sense and you can see it real.

TP: So, you strengthen the signal on the weak signal in order just to hear it or to see it …

SE: To see it. Exactly. To write it on tape. And these, you squelch it down to keep it from just going out . . .

TP: And once you did that, before digital, you could not tell

SE: You did that but you had a data trace that was one amplitude. And you had no idea what had been done. So digital brought about that which ... then that meant that amplitudes were significant and bright spots were meaningful. That is really the secret of bright spots; the early ones, anyway.

TP: O.K., so I got you off track with deconvolution and amplitude.

SE: Well, I hope I made a reasonable explanation of it.

As the lease sales really … 1962, I guess, was the first OCS sale.

TP: Well no, the first OCS was 1954. The 1962 sale was where everything the industry nominated was put up.

SE: Yes, and then that had been set on a three or five year program. They began to set that up. In about 1955 or 1956, some of the early surge came to an end momentarily. Western Geophysical did something very unique at that point in time which was probably one of the real things that made them the power they are. They were working for Union Producing as was GSI. Both companies had one seismic crew working for them. Union Producing shut both crews down. They had done all the work they were going to do until there was some definition or some schedule that they could work with. And they had tons of data. Western made a deal with Union Producing that they would go ahead and just keep gathering data over areas that Union Producing would nominate and Union Producing would pay them for use of the dynamite or some fraction of their cost. That became the first offshore spec. Nonproprietary; nonexclusive, proprietary.

Union Producing were given those data so they had that to work with and Western had the right to sell it.

TP: So, it was just Union Producing? They did not bring in several companies?

SE: No, originally they only had Union Producing.

TP: Why would Union do that?

SE: Well, it was a hell of a deal! They were getting to look at all this vast new territory that they knew they were going to do.

TP: But they had to front much less money?

SE: Well, by then, Union had drilled some successful wells. Block 52 was one I remember. I do not remember the others, but in shallow waters they had a couple, maybe three discoveries. And they knew this was where they were going to be going for a long, long time. That was going to be their happy hunting grounds. And Western just started doing this. There is no telling how much money they made with that because other people were buying the data at reduced prices, fractional prices, and Union Producing was getting a portion of that. So they were turning around and continuing to pay Western this favorable rate to keep getting new data. And that went on for a long, long time.

That was the birth of spec work in the Gulf of Mexico.

TP: So, I mean, the deal was that Union ... proprietary data would cost them a lot more but . . . so Western was shooting the data, Union was paying for their equipment and whatever, and right to buy . . .

SE: They were making some nominal payment to them, yes.

TP . . . and then Western could sell it to other . . . a lot of other companies bought the data?

SE: Oh, yes. Other companies started buying the data. A lot of the contractors took the view, they said, well, this is a grey area. I know GSI said, we do not tell the clients where their data is, they tell us where to go shoot their data. But all those attitudes changed and nearly everything done offshore today is done speculative. I say nearly all . . . there is a lot of proprietary work, but . . .

TP: So, this was in 1955-1956. There was a session in 1958. Well, I know there was a suspension of leasing in this time period because the . . . between Louisiana and the federal government . . .

SE: I can get you some good dates.

TP: I think it was 1957 . . .

SE: That is more like it, yes.

TP: . . . and the federal government reached an agreement to continue the federal leasing . . .

SE: That is more like it, yes. There was a hiatus in the operations. Actually, a lot of the drilling . . . most of the companies in Morgan City and ________ moved their operations out or just shut them down.

TP: And Western continued doing this? When did GSI get into doing spec data? Was it much later?

SE: Much, much later. I am going to say that GSI did not get into the spec area until 1966 or 1967. I could be off on that. The next surge that I recall, and I was not working offshore then, but the next surge I recall was offshore Texas and Louisiana and there were sales coming up. One was called TOG - Texas Offshore, and LOG. Amoco became the operator of these. And they put together groups of several companies.

TP: O.K., this is what I have heard about it. This was not until the late 1960s?

SE: Yes. This was mid 1960s. Let me think. No, I am going to say late 1960s; 1967, 1968, 1969. GSI was selected as the prime contractor for that, the only contractor. They were still using multiple boat operations but they, GSI, had digital recording and they were the only ones who could offer it at that point in time.

TP: So, they were not using single boat?

SE: No, they were not using single boat. They were using shooting boats, separate shooting boats, yes.

TP: In the late 1960s? When did everyone move to the single boat? GSI had the sonic but that was not in the U.S.

SE: It was not in the U.S. And most of the work worldwide was still being done on the shooting boat, recording boat. But they had gone to the yo-yo, letting the streamer go out.

As part of this, there is a little anecdote. People were starting to experiment. They were trying to develop non-dynamite sources. The digital capability gave them recording capability that went beyond the analog systems. They had more dynamic range and they realized that they did not need 50 pound dynamite shots, although that what they were still using! Western had experimented with air guns and Shell was experimenting with an impulsive device. Conoco was experimenting with vibrators. Exxon was developing their hydropulse which was a gas exploder device that is towed in the water. There were just a number of . . . CGG was using a steam-driven device. There was just a whole lot of this going on.

And one morning the people down on the Texas coast woke up and saw these charges laying up near their beach houses that had washed in. And it was not uncommon for a charge not to go off and the explosive was biodegradable, it deteriorated real rapidly. That is the way it was built. But if it got moved quickly, it could end up on the shore and a bunch did. The GSI operation got suspended. The sheriff shut them down!

TP: What part of Texas was this?

SE: I think it was Freeport.

TP: About what year, do you remember?

SE: I am going to say 1967. 1966 or 1967. I can quantify some of these dates. I know people who were around.

TP: We can follow it up, too.

SE: Well, I can either give you names or I can . . . GSI, in the meantime, had gotten into the air gun thing. Bolt was the principal manufacturer of air guns. Western had done most of their work with the real big, large air guns. GSI developed a very small air gun, but many of them and an array of them. And they tuned these to give just the right frequencies that they wanted so that the undesirable frequencies would cancel out and they would get a pulse going into the water, into the earth. They optimized it as much as they could. So they immediately converted their vessels. At one time, they had 23 vessels working in the Gulf of Mexico. I remember that.

TP: GSI did?

SE: GSI did, but most of them were dynamite. But then they

converted to air guns and they became kind of the leading . . . the air gun arrays, the non-dynamite and digital capabilities kind of put them at the lead for a little while. And, of course, then Western got very busy with their devices. They gave up on the air guns pretty early and opted to Esso's dynapulse. It had a rubber sleeve that they had put gas in and explode that, and it would make a big pulse. And they had also developed a small dynamite charge which was a one pound stick of dynamite they would drop, impale down a tube. The end of this charge was a cap, much like a big shotgun shell. And this would strike that into the tube. There was a striker point and there was a delay and this would flip out of the tube and stay suspended in the water for a few seconds, long enough for the boat to move away from it and then it would go off. So, you would get a great big bubble and that bubble would collapse and then it would reverberate. You cannot compress that gas, so it would keep doing it until that gas escaped to the surface. And then they had a deconvolution routine that would debubble. It was actually called a debubble. That was very innovative in that it let them take marine seismic systems anywhere in the world, efficiently and rapidly. They could just ship the cables and detectors and this device, and these little one pound dynamite charges as it were anywhere. They could fly them anywhere in the world, rent boats, ring them up and go do surveys and take the stuff out and go somewhere else.

TP: This came out of Exxon research?

SE: No, this was strictly a Western . . . the minipulse; it was called minipulse and it was strictly a Western development. There may have been some others involved, but Western exploited it better than anyone. About the same time, Conoco, who invented the . . .

End of Side A

Tape #2, Side B

SE: Conoco had been working to exploit their vibrator technology and patents to take it off land and put it on ships in the water. And they did. For the first ones, they took vibrators off trucks and remounted them and suspended them off the side of the vessels. They made some deals with a company then called Olympic Geophysical and Ray Geophysical took licenses and outfitted boats that they operated. Most of the work was done for Conoco in their international and Alaskan operations. But later, Delta Geophysical acquired the patent and the technology and they merged with Seiscom to form Seiscom Delta. They redesigned and built the vibrators. They went to some very large ones.

The vibrator, coupled with digital recording . . . again, digital recording was vital . . . became an excellent marine tool. It never really became pervasive in the industry because a lot of people simply did not like, or did not understand it. But it had tremendous ecological advantages relative to . . .

TP: Dynamite?

SE: Oh, yes. Definitely relative to dynamite. All of these new devices seemed to get around all the problems of fish kills and that sort of thing. And there had been some of that off the Texas Coast during the . . . so, the vibrator developed and it probably would still be today . . . in fact, there is a company still doing research on it - PGS and some of the other companies, CGG, are working on vibrators as an ideal source. But operationally was undesirable, because with the vibrator you put in a signal for 10 or 12 seconds. Then you have to listen for another 6 or 8 seconds, so that each reflected event is actually 10 seconds of signal plus the amount of time that you listened. But through process of correlation, cross-correlation, you collapse that down. And it had tremendously good signaling noise. And a lot of people, they wanted it more . . . Texaco and Canada, I know, all of their work offshore in Canada was done with that because they thought it had unique capabilities.

But eventually, the whole industry went to a guns. A mix of technology, both by the air gun people and . . .

TP: Was the problem with vibrators was that it took too long?

SE: You did not have enough time because if you slowed down to do the amount of sweeping, inputting that you need to, you became too slow which was operationally not good if you did not gather as much data in an hour's time or a day's time.The streamer cable has to be towed at a pretty nice speed - four to five knots. If you slow down to two or three knots like you would have to do to use the vibrator, then it begins to drift and lose streaming capabilities. So, it was more of an operational disadvantage than . . .

TP: It had a good signal . . .

SE: Oh, it had an ideal signal particularly putting it in water, then what you are getting going in is just exactly what you wanted.

TP: But the industry eventually went to air gun. When did that become the standard?

SE: I am going to stay it started about 1972 or 1973. Maybe as late as 1975. I do not think there are any other sources being employed today and have not been for 10-12 years, maybe 20.

Going back to digital, again, one of the things that really came out of the digital capability for the industry, not just marine but land, was the ability to extract velocities from the data. This started when people started doing multiple coverage, and having multiple looks at the subsurface you could then do some algorithms and you could actually discern what the velocities to these different reflectors were.

TP: This is common depth point?

SE: Well, it part of what makes common depth point, yes. Go back to what I told you: we had single spread and we would shoot in the middle, 6f60 each way and then we would pull up 6/60 and shoot again. That was single coverage. No common depth point. Now, you could pull up just a short distance and shoot again. Then you duplicate the subsurface, pull up a short distance and keep duplicating. Then you would stack those data together at the common points on the subsurface and you get CDP, common depth point.

But, knowing how to correct for the different rate paths is important and velocity is a very key part of that, specifically what we call normal moveout because the time to reflector, directly at the reflector and out here, the time greater because of the longer travel path and the time right here. So you have to know what velocities these things have propagated so that you can correct for that distance; so that you want to make every point that you are summing as if it were directly under the surface. That is the whole essence of common depth point.

In 1969, and this was during the offshore Texas thing, Amoco was the operator, and part of their responsibility . . . GSI would gather the data and process it up to a certain point. It would then be looked at by Amoco representatives and they would select what correction velocities were going to be applied to stop the data. So here, they had many, many miles of data gathered and taken up to a certain point, ready to stack and finish and give to the clients; there were multiple group clients. And they just could not make up their minds about the velocities. GSI's contract, I believe, was such that they did not even get paid until they delivered the data! So, a fellow named Bill Schneider and Milo Backus, two of the research geophysicists at GSI, devised a means of extracting those velocities from the data themselves and that gave rise to velocity analysis or velocity spectra -- there were a lot of names for it. And it really kind of revolutionized processing. They were then able to do things because the data were digitally recorded and lended themselves well to these entity-type approaches. Economically, they were able to extract the velocities from it and utilize those. And, of course, that is the whole essence of 3D today, not only the simple stacking velocities but sheer wave velocities and converted waves and that sort of thing. The whole secret of 3D volumes is developing velocity fields of the area that you are doing 3D. So that goes back to Backus and Schneider.

TP: I heard somewhere that the first 3D was shot in 1967 in the Friendswood field. Is that right? By Exxon?

SE: Exxon, yes. And I think what they did then was. . . and there is someone who was associated with that that you could probably talk to . . . they recorded these data and then they played them out in paper records or films and hung them from the ceiling.

TP: Joe Pratt interviewed a guy from Exxon about that and he got that story.

SE: That was really one of the early . . . they did not have the wherewithal to do it and look at it on a computer, so they hung it from a big room. I have seen pictures of those records. Not necessarily that one but some other places. There are a number of Exxon people around . . .

TP: I can tell you who it was.

SE: Maybe Hugh Hardy?

TP: No. Anyway, I have the name. We have to put that story together.

SE: Oh, yeah. There is a lot of controversy about who and where were the first 3D surveys done. The first one on land was done out in the Bell Lake field; true 3-D.

TP: What positions were you in over this entire period we are talking about?

SE: When I first went to offshore, I was originally a computer and then a seismologist. Then, I worked in Venezuela, in Lake Maracaibo, as a seismologist.

TP: In the late 1950s or so?

SE: Yes, that was 1955. Then, I became a land party chief and I spent several years working on land. In 1969, I moved to Houston and then became again associated to some extent with the marine operations. I left GSI and went to Seiscom Delta as an area manager and I was responsible for three vessels. And those were all vibrators. We actually had one of the EPR gas exploders.

After that I left, and I spent the rest of my time mostly in land operations. The last 12 years, I was with Grant Geophysical in charge of their international operations. Well, we did have a period in there of some marine activity, but I was not involved with that or the Gulf Coast, for that matter.

TP: How did the technological development of seismic operations on land and on water differ or reinforce each other over time? I know it is much cheaper and more efficient on water.

SE: The real early efforts were really just an extrapolation of land techniques into water. You mentioned marsh buggies there. Some of the real early shallow things were marsh buggies going out as deep as the could into water and deploying cables on the ground. And then they started dragging these cables with vessels. So that was really an extension; the detectors were land, the dynamite in holes or in water was land extrapolation.

TP: And the geofoams were the same? They called them hydrofoams on the water?

SE: Well, originally, they did not have hydrofoams. The thing I mentioned on the Sonic, the streamer, was the first commercial hydrofoam. The USGS and some of the government agencies, the Navy, had big pressure detectors that is a hydrofoam. But they are used for totally different things. The early hydrofoams, just like everything else, they got down to where they were just little small things now.

The technology . . . most of the digital things that really started on the land and were first applied to land but the big market for velocity was where you had these huge volumes of data that you needed good velocities or you had to process them and process them and process them; trial and error almost. So the big application of velocity and early deconvolution, the real application, was designed for offshore problems; both the velocities and deconvolution. And, of course, true amplitude recovery or gain recovery gave birth to the bright spots. You are probably getting a lot of amplitude anomalies now being mapped on shore and things that they call ABO, but bright spots were sort of a serendipity from doing things correctly with the data offshore. And the Gulf Coast, in particular, lends itself extremely well because of the geologic nature, the rock nature. It is why ABO has been successful offshore.

TP: Do you remember when this was all happening, the bright spot issue? I mean, a lot of people thought it was too good to be true and a lot of people theorized about direct detection of hydrocarbons.

SE: Shell was one of the first to quantify amplitude anomalies. That is the way I would word the bright spots. This fellow named Cecil Craft, he was ex-Shell and he had been involved with them. So, no I do not know when Shell jumped onto that. Cecil had a data processing company here; I cannot remember the name now, but he gave several papers on the bright spot and quantification of amplitude anomalies. That would have been in 1970. But Shell had been using it for quite some time.

TP: Mike Forrest said it was around 1967 when he f started thinking about it. But people like Carl Sabat had theorized about it early?

SE: Yes, I think if you look at some of the literature . . .

TP: And there were some Russian geophysical abstracts that might mention it?

SE: There was an Amoco brilliant person. I think it was Widess. Widess and Silverman were two Amoco research types, and I believe they published some very early publications on the significance of amplitude and what was required to recover it -- mainly for mapping thin layers because if you distort the signal that you are looking at with the recording devices, then you lose your resolution and thin layers.

We knew that Shell was doing quite a bit of amplitude work and also using the conversion of waves at the water bottom to generate sheer waves, and then they were able to quantify conditions at their target zones. We know that was happening in about 1970 or 1972. That meant that they had done their basic research back into the late 1960s.

TP: Bright spots were used primarily to map gas plays, but they were useful for oil, too, right?

SE: The bright spots . . .

TP: They were phony bright spots?

SE: Well, for example, there was a huge discovery in the Gulf of Thailand; a big, big, classic bright spot. One of the early marine 3Ds, was done on this by one of the former Dallas companies. But anyway, they made a tremendous discovery of carbon dioxide. That was gas! But later, they were able to use the data and they did discover huge methane reserves in that particular field. But, what they drilled first was C02. So, gas is the cause of the bright spot.

A gas saturated zone has a much lower velocity than the zones on either side of it, particularly if there are oil saturated zones below it. And it is those boundaries that give rise to the bright spots. And when you have gas inserted into shale or sands, you have a very low velocity here, and high velocities on either side, so you give rise to very strong . . . the gas reduces the velocities in these zones, the presence of the gas, so that this thing sticks out, it comes out as a high amplitude. And it disappears. You will have a high amplitude here and then it will taper out and then it will disappear. So you end up with these big bright spots, and that is a bright spot. They now know how to quantify those, but trust me, there were a lot of leases bought and a lot of dry holes drilled on some bright spots that . . .

TP: Oh, I remember, in the early 1970s . . .

SE: Texaco went into a huge leasing program offshore Texas.

TP: I think Mobil, too, leased a bunch of properties that turned out to be phony bright spots. That is an interesting story.

SE: Well, it is. It is typical of the geophysical business, we jump on these band wagons and it is the discovery d'jour. Shell was usually leading everyone, but by the time you hear about it, they have already gone to something else almost. But they would hear that Shell is doing this and they are just frantically trying to find out what Shell is doing. And they'd start doing it, with no reason whatsoever except that Shell doing it!

TP: Can you talk about this contractor industry and the different companies, the different cultures, say, in Western versus, you know, GSI, versus Seiscom Delta? Or is there a lot of fluidity between the people who work in these companies and the relationship with . . .

SE: Well, for many years, it was not. Back when offshore things were starting, companies were doing a lot of hiring out of college and training their own people, growing them.

TP: Where did most of these companies recruit?

SE: Well, of course, the choice ones came out of the Colorado School of Mines. Geological engineers from Oklahoma. MIT was the source of most of GSI's group of "diginauts" as I call them - the people who really caused the digital revolution to happen. They would recruit math, physics, and geology majors; pretty much most of the physical sciences. People with those backgrounds could adapt into that.

GSI for one . . . I am sure others had a real extensive training program, correspondence training program. It was later purchased by Aramco and some other oil companies for their own people.

In the early days, they trained their own people. You would have people proselytize from one company to the other, but not very often.

TP: GSI was based in Dallas?

SE: They were in Dallas.

TP: Where was Western?

SE: Western was in Pasadena for a long time. They later moved to Shreveport when they were enjoying that close relationship with Union Producing, which was their headquarters. Then Western later moved here. And then they later built that building ... they have got a large complex out on Richmond.

For a long time you had Western, GSI, Robert H. Wray, which later amalgamated several companies into Geosource. United Geophysical was a major player in the world. I am skipping several, I know, but they had unique capabilities, there was strong competition, but people did not change between them very much. Then you had a growth of new companies when everyone could go out and buy the same instruments, which TI would sell to them, and they were the main supplier . . .

TP: Was there an association of geophysical contractors that helped promote the standardization of instruments?

SE: No. There is one now. There is an IGC - International Association of Geophysical Contractors, but there has never been anyone -- the competition did it. And you sold your services on your capabilities. And that includes your instruments, your people, your experience in a given area, and your relationship with that particular client. And clients would come to the contractors and say, we want two seismic vessels or marine crews to work for the next two years in the Gulf of Mexico, and they may or may not get bids, but if they wanted Western that is who they would come to and negotiate the deal with them. That is the way Union Producing always did it.

But those days are not here anymore; it is strictly low price today. The oil companies will, and these are often set out by their accountants, the users will specify exactly what they want and give it to everybody who can supply it. They get the bids in and the conditions are such that everybody has got to provide the same quality of work, have the same safety records and safety capabilities, and it goes to the low bidder. The work is pretty much uniform.

TP: There has been a consolidation . . .

SE: Oh, yes. There are only really about four suppliers now. Western now with Schlumberger and Geco. And Veritas is merging with PGS. CGG is still one of the few. Who am I missing? That is pretty much it. And so, you learn about those four companies they have consolidated and are carbon copies of each other. They have stayed afloat, literally, in the marine area by doing extensive spec surveys of one type or the other. They call them multiclient, mainly because they usually find one client who wants to work in an area and they will pay a portion of that price. The contractor gets to sell the data as many times as they can. They recover their costs and some level of profit maybe, and then the original underwriter or underwriters will start receiving some sort of . . . that is the typical spec approach.

TP: ____

SE: ____

TP: And spec data really took off in the 1970s?

Yes. Western, as I mentioned, started it. GSI finally went into it. Geosource, which later became Haliburton and GSI, is no longer there; it is now Western. Geosource adopted a very unique approach. Once the blocks were announced, they would run boats out there and they would shoot high detailed 2D - this was pre-3D days
- across those blocks and presell it. Once they would get started shooting, they would go to their clients and say , this will be delivered on such and such date, well in advance of the sale, and they would shoot up all the blocks, just the individual blocks; whereas, today, you are shooting huge, vast 3D series over the entire …

TP: So, most of the spec data done today is 3D?

SE: Oh Yes.

TP: It was so expensive for a long time. I mean, you did not really start hearing about 3D until the 90s, but 3D has been around a long time. It was so expensive that companies really did not use it in exploration. Is that right?

SE: Oh, yes.

TP: It was mainly for sort of delineating discovered f ields right?

SE: No, I think you are right. People jumped in as early as they could to shoot 3D . . . instead of just shooting a block, shooting that and shooting adjoining blocks. The block for sale may be in the center and they would shoot 9 miles in each direction. And then, this block would come up for sale but then people would then start buying the adjoining blocks because you can almost do that whole 3 x 3 by the time you could do the 1 x 1, by the nature of the operational techniques. But then, that 9 x 9, or 3 x 3 block thing grew into a whole entire base or whatever.

TP: A whole entire planning area.

SE: Yes. One of the real big factors in offshore efficiency has been navigation. I mentioned earlier that in the early days you could work from dawn to dusk and you spent a lot of time making sure that your surveying was correct. You may have to actually pick up everything and go to a well location and get your tieback in there and then leave the next morning. It was a terribly inefficient approach. Satellite .

TP: . . . Global positioning . . .

SE: GPS came on and the seismic industry jumped on that, big time. In the early days, you just had a few satellites, you'd get a fixed periodic . . .

TP: This is what period? In the 1970s?

SE: 1970. In 1972, I was the coauthor of a paper- the first satellite navigation paper that came out.

TP: Oh,

really? SE: Yes.

TP: Where was that?

SE: That was in the EAG. I am trying to remember if it was published in. . . .it was not in Geophysics. It was published in the European journal. I can get you that. I can add some of this stuff when we do this. That was 1972. A company called SPC - Satellite Positioning Corporation, in California - devised one of the f systems.

You would get a fix, and at that point in time you would have a pretty narrowed down location of where you were. So it might be another two hours or some length of time before you would get another fix. In the meantime, you are gathering data. So, the company developed Doppler sonar as a means of running a tract between fixes. And so, maybe currents drifted you off, but then all of a sudden you would get a fix here and you wanted to be here, so there would be an adjustment and you would get back where you were supposed to be when you get this f so that you would be able to correct this. You are thinking you are here, but you are actually here. So, there was some periodicity that you had to fix.

Until the government put up an abundance of satellites like we have today, that was the way that it was done. Doppler did not work well in real, real deep water. In those days, however, this did let you work 24 hours a day. And that meant that instead of 30 days times 8 or

10 hours, 240 hours of recording; all of a sudden, you are 24/30. And this made a tremendous impact on the cost of data because the boats got there, it is running, the people are there, everything, the costs remained the same, but you are gathering more data. That is why 3D has become very reasonable; you can put more streamers out, that gives you more data per impact, per shot, and you are working 24 hours. So, marine 3D is probably the best deal in the world. It is really the only way people do their proprietary work anymore. They know that they want to develop a field or they want to do some of the more sophisticated three component and foresee the time lapse … I do not know if it is time lapse or elapse…

TP: Time lapse.

SE: Time lapse, yes. That is where you study a reservoir and then you come back and you state it again and you see how the oil has either migrated or diminished, and that sort of thing.

TP: And so, people are using 3D for exploration?

SE: Oh, yes.

TP: The drilling accuracy is incredible.

SE: Yes! How you get a mile away and track a 30 foot sand or a 3 foot sand and stay in it is beyond me!

TP: Well, that is interesting. Can you think of other interesting stories that you might have from your days at GSI or afterward?

SE: One of the key things, going back to changes in energy sources, when we got away from dynamite was the safety aspect. The contractors had some bad accidents around the world. The sheeting boats, they carried the dynamite and would actually come in and drop the things in the water and get away from it and shoot the shot. They would make these charges up on a table, as it were, and then this table would tilt and this whole thing. . . they would tie the float to it and put the detonating cap in the charge. And when they moved in, they would just tilt this table and it would slide into the water. It had a big electromagnetic capturing cage because the cap's wire acts as an antenna and there is enough power in electromagnetic transmission of the radios to actually detonate those caps. So, safety was a big factor, and there were some bad accidents.

I remember one in Saudi Arabia . . . fortunately never on the boat, which would have just completely taken the shooting boat, but in the water. There were some deaths. So that was a big motivation, a big driver, to get nondynamite sources out there.

TP: Not to mention the undetonated floating . . .

SE: Yes, well, that really brought about the sheriff of Wharton county or Jackson County! All the credit goes to him. He shut them down, big time!

TP: The crews were recruited locally?

SE: In those days . . . they were well-trained. You would pick up some deck hands or somebody to handle the cables, but the key personnel were longtime employees. Back then, before you could work 24 hours, they would typically work out 10 days and come in 4; or 20 and 8. They would bring the boats in, everybody would get off, go to the bars, stay there for 4 or 5 days, then shore up and go back out.

I remember the thing I hated the most was working in the office. When the boats would come in, they would send the supply boat in to get more dynamite. And these were huge quantities of dynamite -- I remember those hulls were full. So, the dynamite suppliers would be up at dock, the boat would come in and the dynamite had to get from the suppliers' trucks into the boat. Well, we would clean out the offices. We would get people out of their offices to get in the car and go meet the boat. And we would load those things! And then, you know, they had to be loaded from the supply boat into the shooting boat when they got there.

Weather, of course, was a big factor.

TP: The suppliers did not do the loading? Or, you did not want the suppliers to load?

SE: Well, no. They had a driver! They were not about to get out there and do that! Sometimes we would hire some locals. And, of course, the dynamite is not truly . . . it was really a mixture of ammonium nitrate and insensitive to . . there was no danger of it being detonated like real high velocity dynamite. It was basically inert until it was armed.

TP: I see. When did the processing take place on the boats? Did that come with digital recording?

SE: That really came about with some of the smal computers. In the early processing days, you were looking at big IBMs and CDCs and rooms full of computers; big rooms with a lot of tape drives, typical computer centers. And the data had to be brought in.

TP: And you would spend days processing some of the data.

SE: Weeks. Just reading the tapes. And there were all these problems with the tapes skewing and that sort of thing.

TP: Shell built their big data center out on Old Spanish Trail.

SE: Yes, out there by the Astrodome.

TP: And it was strictly for geophysical processing. The computer capacity they had was, I think, second to NASA in the area.

SE: That is right. Well, the early computers had a very low capacity. Mobil, Texaco, and GSI had the first digital computer designed to do seismic data. And that was part of the digital revolution . . .

TP: There was a consortium?

SE: GSI conceived the digital concept - converting from analog to digital - and being able to do things that they knew could be done. And this was done mostly by the MIT group that I mentioned.

TP: Was this Milo Backus?

SE: Milo. Mark Smith. Bill Schneider later came but he came from Wisconsin. He was the Wisconsin grad.

TP: Bob Gravener?

SE: Bob Gravener was not in that particular group but he was the area geophysicist who kind of acted as the guide. Bob took things from the research and development group, sold them, sold clients on them, and actually saw that they got operative in the field or that they got operative in the processing. GSI approached a number of their key clients and proposed a consortium, as it were. They were seeking assistance in doing this. They approached some of their real key clients. It turns out that Texaco and Mobil opted to join them. For doing that, they had to buy a certain number of field systems that were to be developed and a ceratin number of computers, and they were to contract so many crew years of crews. And for two years, GSI could only provide digital technology to those two people. So that Texaco and Mobil had that exclusive for two years.

TP: When was that?

SE: What year? 1962 was when the first crew went to the field. It was a land crew. Both of them took those crews for a while. Texaco was the first one to take offshore crews. They had two or three operating.

TP: The first to take digital?

SE: Yes, digital offshore.

TP: They were their own crews or they were GSI crews?

SE: They were GSI crews, and GSI set up a huge processing center in New Orleans that, by and large, was Texaco. It was interesting . . . GSI would develop new techniques and they would go present it to Texaco, and Texaco would say, "Let's redo it." And they would go back and they would start all over with huge amounts of data and apply that. And, I mean, processing prices were really ripe in those days. This was just plain old simple 100% data, for the most part. And then, as the CDP came around, well then that just kind of compounded it. Mobil later got into the offshore stuff. And then when this two-year moratorium was over, Exxon jumped into the offshore thing with GSI.

TP: A moratorium on Texaco . . .

SE: Yes, the constraint of no other contracts. And there was a real vigorous amount of development in algorithms and techniques that came about. I wish I could remember some of the other names. I will give you some of the others, but Schneider and Milo were really . • .

The whole concept started with a guy named Ken Berg. Ken was the vice-president of GSI . • . the concept of the digital application, digital application for seismic.

TP: Ken Berg was vice-president?

SE: Ken Berg was vice-president of technology for the company, and he was one of the real early people there. A wonderful guy, a wonderful man. Mark Smith was in charge of the group, and it was Mark who really shepherded the whole thing through.

TP: He was another MIT guy?

SE: Yes, he was the MIT guy. He put together the team that really made it work.

<u>End of Tape #1, Side 2</u>

Tape #2, Side 3

TP: So Mark Smith was in charge of the technology group that included MIT . . .

SE: Yes, that is right. Really, it was Milo and Schneider who were the big contributors but there were others. John Berg, who was Ken Berg's son . . . and I call him the father of deconvolution… he was in that group and became a very big contributor. He later left and formed his own company, and I do not recall the name right now -- Entropic. He is recognized as really one of the top signal processing people in the world.

I might mention that TI had a contract with the Air Force to develop stations for monitoring nuclear tests. And they set up monitoring stations in various places around the United States. And in the development of that they developed a lot of signal processing approaches to extract those real low level nuclear blast signals coming from Russia and wherever, to extract that out of the background noise. When you are passively sitting there recording you have got all of the trapping noise and everything but they selected sites in Tennessee and other places . . . the government actually selected the sites, I think. But, TI staffed and ran the operations and they actually processed in real time. So that was kind of a forerunner of some of the things and they were able to take things that they developed there and take them into the digital oil and gas world.

TP: So, GSI was the first to move to digital recording? When did Western and some of the other companies follow? Was it closely?

SE: It was as closely as they could, yes. Typical Western ... Western always liked to do their own thing. They had a style, and they were very good at it, of seeing what other people were doing or waiting and letting other people . . . and then doing it a little better. That is just my personal opinion.

TP: Sort of like the Japanese!

SE: Yes! There was a company here called Geosource and they built a very good analog instrument. When GSI could not provide their instruments and processing to other clients, Geosource developed and built them a system. It was actually used in Germany first; there was lots of trouble with it and it never really caught on. Western built their own in concert with another company and I do not recall who that company was; it was an instrumentation company.

There was a company called Wray Geophysical, which later became _________ and later became Geosource, but they merged ... Wray was bought by a company called Mandrell and Ampex. Ampex was a major manufacturer of tape drives and other things. The Ampex tape drive was the tape drive used in the first field digital systems; one inch tapes. Wray Geophysical, through Mandrell, were also building instruments and Mandrell actually built one of the early very good ones. They built a very good one. And they were one of the first ones who could actually take repeated shots or air gun pops or ________ sweeps and sum all those together in the field. And that was probably one of the earliest parts of field processing. So you basically had Mandrell and TI, but TI just kind of swamped the market. Once they could sel1 to anybody else, they started developing a whole series of new systems and each system got smaller, with more resolution and a higher dynamic range. And they became the dominant instrument in the market, so everybody could go buy TI field systems.

TP: Digital recording systems?

SE: Digital recording systems. But most of the companies

. . . Amoco,Shell, Exxon, Chevron . . . opted to go with other computers. I think Shell went with . . . I do not recall what they went with, but Chevron went with IBM and Amoco went with IBM. Different ones went to large computers and they developed their own instead of buying the TI computers. TI later expanded their initial computers into some very large capabilities and they sold a few and used a few, but it could not compete with what was coming out almost new every year with some of the big computer sales people.

Going back to your question on board processing, that came about as you had real fast processing systems developing and miniaturization, smaller. The classic laptops that now can process if you want them to, and they do.

There are still some pretty good, not physically large, but some very large capability computers on boats. And the boats are large now. The boats are huge compared to what they were many years ago.

TP: I remember the Shell American was a big step in Shell's fleet. Well, this has been very helpful, Sam. I do not want to keep you too long.

SE: Well, I am going to depart, but if you want to do it some more . . . these are thoughts that I have had before, from after we visited, but if I think of anything else I will make some notes and if you want to take advantage of them, well, that would be fine with me.

TP: I will stop the tape now.

THE END