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Alfred G. Brandstein Interview (MORS)

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Military Operations Research Society (MORS) Oral History Project Interview of Alfred G. Brandstein

Cortez D. ''Steve'' Stephens

Marine Corps Combat Development Command
cortez.stephens@usmc.mil

John Bruggeman

Marine Corps Combat Development Command
John.bruggeman@usmc.mil

MILITARY OPS RESEARCH HERITAGE ARTICLE

INTRODUCTION

Oral Histories represent the recollections and opinions of the person interviewed, and not the official position of MORS. Omissions and errors in fact are corrected when possible, but every effort is made to present the interviewee's own words.

Dr. Alfred George Brandstein (AlGeBra) brings more than a clever signature to the practice of military operations research. His accomplishments in studying the MV-22, the creation of Project Albert, and the founding of the field of Operational Synthesis are evidence of his unsurpassed leadership and contributions to the field. But his real hallmarks are a troika of characteristics blended in a way that are legendary, at least within Marine Corps circles. The first is audacity: he strives to answer questions others would not even dare to ask. The second is humility: his actions are a testament to the tenet that you can accomplish much if you don't care who gets the credit. The third needs no example and indeed summarizes the man himself: integrity.

Dr. Brandstein holds a Bachelor of Science degree from Brooklyn College, with majors in Physics, Mathematics, and Astronomy, and a Ph.D. in Mathematics from Brown University. Dr. Brandstein joined U.S. Army's Harry Diamond Laboratories in 1972. He became a member of the Marine Corps family in 1980, when he joined the Analysis Support Branch of the Marine Corps Development Center. During Desert Shield/Desert Storm he was Director of the Marine Corps Operations Analysis and Assessment Group (MCOAAG). He eventually became Chief Analyst, a Senior Level (Senior Executive Service [SES]-4 equivalent) position, at the Marine Corps Combat Development Command (MCCDC) and the Director of Project Albert for the Marine Corps Warfighting Laboratory.

Dr. Brandstein, who has authored several hundred professional papers, is a recipient of the Army Development and Readiness Command (DARCOM) Systems Analysis Award, the Marine Corps Meritorious Civilian Service Award and the Superior Civilian Service Award. In 2000, Dr. Brandstein became the winner of the MORS Clayton Thomas Award.

MORS ORAL HISTORY

Interview with Dr. Alfred Brandstein
October 20, 2004
Woodbridge, Virginia
Cortez D. ''Steve'' Stephens and Major John Bruggeman, Interviewers

Steve Stephens: Dr. Brandstein, please tell us where were you born.

Al Brandstein: Brooklyn, New York, October 1938.

Steve Stephens: Tell us about your family.

Al Brandstein: My father was a doctor; my mother ran a bookstore, and I have one sister who is eight years younger. I grew up in Bensonhurst in Brooklyn, and my father went off to World War II. When he came back, we moved to Sheepshead Bay, also in Brooklyn, and I went to elementary school, high school, and college there. I went to Brooklyn College, which was two bus stops further on than the high school.

Steve Stephens: Dr. Harris was also raised in Brooklyn. [Note: Dr. Carl M. Harris was Professor of Operations Research at George Mason University. In 1999, Dr. Harris won the INFORMS George E. Kimball Medal, in recognition of his many years of distinguished service to the OR profession.]

Al Brandstein: A lot of people were raised in Brooklyn. I think Brooklyn has produced more mathematics PhDs than any other place—and Brooklyn College, specifically.

Steve Stephens: How far did you go at Brooklyn College—all the way to the PhD?

Al Brandstein: No, not at Brooklyn College. I didn't know what to do after college was coming to an end; the thought of work was an effort. So I decided to go wherever they'd give me the most money and Brown won out. Brown and math won out by $50 a year over Cornell and physics and by $100 over Michigan and astronomy.

Steve Stephens: That was your measure of effectiveness?

Al Brandstein: I didn't know what else to do. I was a naive little kid. I didn't know what I was going to do except I knew I didn't want to work.

Steve Stephens: Can I back up a little bit? You went to public schools in Brooklyn. Then you went to a public high school?

Al Brandstein: Yes, the high schools, at least the one I went to, were a little bit different from what you'd expect. We had the

advantage of being as far away as possible from the Bronx High School of Science and still be in New York City.

Steve Stephens: The advantage of being far away from it?

Al Brandstein: Yes. If you wanted to have a really good education and not spend half your life on the subway, you went to my high school instead of going to the Bronx High School of Science. I'm told that our graduating class turned out 350 MDs.

Steve Stephens: Was it a large class?

Al Brandstein: About 1,600.

Steve Stephens: The name of the school?

Al Brandstein: James Madison. Our math team competitions were better attended than the football games and in the year I graduated we had a first and second in the Westinghouse talent search.

Steve Stephens: So in high school your love was for mathematics.

Al Brandstein: Yes. High school math then was very different from today's high school math. There was no concept of having calculus in high school. What we did have were subjects that you don't take any more. For example, higher algebra that deals with difference equations and the binomial theorem with arbitrary exponents. There was spherical trigonometry and solid geometry. I do not see those subjects in high school anymore.

Steve Stephens: How did you choose Brooklyn College?

Al Brandstein: It was easy; it was just two bus stops further on than the high school. Another reason was it was $8 a semester for tuition and I had a $350 a semester scholarship. And I was socially immature—the thought of going away to college never occurred to me and all my friends went there. Another interesting point is that in junior high school, all my friends and I skipped the 8th grade.

Steve Stephens: You ran with a fast pack.

Al Brandstein: I ended up with a severe inferiority complex. I remember taking algebra in 7th grade and everybody on all sides of me was studying differential equations. They were very—I guess fast would be the case.

Steve Stephens: And your major in college?

Al Brandstein: Physics, math, and astronomy—all three.

Steve Stephens: Three separate majors or was there one major that combined the three?

Al Brandstein: No, three separate majors. The thing I disliked about Brooklyn College was that it was the largest liberal arts college in the world at the time and they made you take a lot of liberal arts, so I didn't get to take as many hard science credits as I wanted to. I went to summer school to gain more credit. I ended up with 40 credits in physics, 36 in math, and 20 in astronomy.

Steve Stephens: When you were at Brooklyn College, did you have a preference between the three?

Al Brandstein: No I liked them all except I became a little disillusioned about physics. When we took quantum mechanics, I didn't like the idea that electrons could go from one place to another and get to the second place before they left the first. I decided that if that's the way the world is, I don't want to live in it. But then, if Cornell had offered $50 more I would have been a physicist.

Steve Stephens: So there you were, majoring in physics, astronomy, and mathematics. And you went directly to Brown; you didn't go into industry or military service?

Al Brandstein: I was fortunate enough to go to graduate school right after Brooklyn College. At that time, the government was desperate to get scientists because of Sputnik. The only criteria that they had were aptitude tests like the Graduate Record Exam and I do well on aptitude tests but not on achievement tests. Our standard of living in graduate school was high. You have heard of poor starving graduate students—that was not the case. [Note: On 4 October 1957, the Soviet Union successfully launched Sputnik I. Sputnik was the world's first artificial satellite and was about the size of a basketball. That Sputnik launch marked the start of the space age and the US-USSR space race. Source: http://history.nasa.gov/sputnik]

Steve Stephens: Did you consider medical school?

Al Brandstein: My father talked me out of it. He was a physician and he hated his lifestyle. That's the primary reason—he was very unhappy with it.

Steve Stephens: How long were you at Brown?

Al Brandstein: I'm ashamed to say—13 years. In part, it was because I'm a slow learner, but also in part because the money was so nice. For the last seven years there I was also an assistant professor at the University of Connecticut. I taught all the undergraduate math courses and some graduate courses. I had a bunch of students.

Steve Stephens: What was your specialty as you went for your PhD?

Al Brandstein: It becomes interesting later on, it's a field called functional analysis. It's using the techniques from one major discipline say, algebra, geometry, or calculus to do problems in another discipline. For example, you take a geometric problem and see if you can convert it into a continuous problem, solve that and then go back into the geometric domain or go into an algebraic domain. My thesis was on Swiss cheeses, I actually have a theorem that sometimes gets quoted. It is concerned with finitely generated, antisymmetric algebras and their deficiencies. I was able to show that every two manifold is a maximum ideal space of an algebra of arbitrary deficiency. I'm sure it doesn't mean anything to the world at large but the only ones known at the time were the real projective plane and the sphere.

Steve Stephens: When you were at Brown, did you ever come across the term operations research or operational research?

Al Brandstein: Never!

Steve Stephens: Was the term ''applied mathematics'' in vogue?

Al Brandstein: Applied math was certainly in vogue. Brown is very famous for its applied math department, its computer science department, and history of math. But in my day, if you committed computer you were drummed out of the math department.

Steve Stephens: I have never heard that term before, ''committed computer.''

Al Brandstein: If you used the computer, they stripped off your buttons and sent you over to computer science or applied math.

Steve Stephens: Applied math and computer science were looked at in unfavorable terms?

Al Brandstein: No. The criterion for getting a PhD in math at the time was aesthetics, how beautiful your theorems were. It turned out a couple of mine were appealing, I suppose. I'd only had one computer course in my life going back to Brooklyn College. It was, maybe, 1958 and the course was on a Univac I. Univac I was before the days of assemblers and compilers. You had to write in machine language and a lot of people hated it. I liked it.

Steve Stephens: I'm going to ask you to go back and explain the significance of Sputnik.

Al Brandstein: At the time, I was part of the Moon Watch Program, which was supposed to look for the Navy's satellite, Vanguard, the one that kept falling over on its face. When Sputnik went up, it was quite a surprise. NBC let us use the roof on the RCA building to watch for it. We had set up these telescopes. But that's not the question you're asking, just an interesting sidelight.

The country was very desperate about the science, engineering, and math gap that apparently the Sputnik seemed to point out. So the government threw millions, maybe billions of dollars into trying to get people to go into science. I had a National Science Foundation Fellowship that came out of the Sputnik fallout. You qualified for it by taking the Graduate Record Exam. As I said, I do quite well on aptitude tests. So I got a high score and came out with lots of money. I kept that fellowship for the whole time I was in graduate school. I had that plus I had the salary as an assistant professor. You can't beat that. By my first year in graduate school I had saved enough money to buy a new car and a mink coat for my wife.

Steve Stephens: When did you marry? Did you meet while you were at Brooklyn College?

Al Brandstein: No, it was later. I was teaching astronomy at a camp in the Adirondacks—one of those rich kid camps. Donna was teaching flute and drama. We met up there in Lake Placid. It was 1961; we got married in 1962. They even gave me a honeymoon fellowship. If you're getting married during the summer they gave you a fellowship to cover that.

Steve Stephens: Where did you go on the honeymoon fellowship?

Al Brandstein: Miami, on the recommendation of my father-in-law.

Steve Stephens: When you left Brown, where did you go next?

Al Brandstein: Harry Diamond Laboratories.

Steve Stephens: Where is Harry Diamond Laboratories?

Al Brandstein: There were ten of them. Nine of them were in Maryland. At the time they were on upper Connecticut Avenue. The tenth was located here in Woodbridge. That's why we moved to Woodbridge.

Steve Stephens: How did you become involved with Harry Diamond Laboratories?

Al Brandstein: I was at some party at my sister-in-law's house in Alexandria. She has an office still in Woodbridge; she's a plastic surgeon. So she had a graduation party, I think it was for a medical school or internship, and I ran into a next-door neighbor who happened to be a GS-17 or GS-18. They didn't have SESs at the time. We got to talking and she said, "Send me a resume," so I did. Lo and behold, they offered me the job.

Steve Stephens: Describe the type of organization that Harry Diamond Laboratories was.

Al Brandstein: I can't describe the whole thing, but Harry Diamond, if the myth is right, is the one who discovered proximity fuses. The Harry Diamond Lab here in Woodbridge did electromagnetic pulse (EMP) work. [Note: Harry Diamond was born in Russia on 12 February 1900 and immigrated to the U.S. as a child. Through his vast knowledge in the field of electronics, he contributed greatly to the fundamental concept and design of proximity fuses. Source: http://www.goordnance.army.mil/hof/1969/diamond.html]

Steve Stephens: This was a government organization?

Al Brandstein: Yes, US Army.

Steve Stephens: So you left Brown and became a civil servant.

Al Brandstein: Right. It turns out that every self-respecting lab has a slot for a mathematician, but they didn't have the slightest idea what to do with one. I worked in a group with three physicists who were also superfluous but it was felt that a lab needed physicists and this was a lab. The first thing I did there was to write, with one of the physicists, a paper on Fourier transforms. We came up with a scheme to do more accurate approximations to functions and then use an advanced Fourier algorithm to evaluate the transform event.

Steve Stephens: What type of automated computer support did you have to do that?

Al Brandstein: We had a thing called a Mohawk. It was in a room about the size of this one, maybe 20 by 30 feet. It was filled with computers with tape drives and a card reader. It was a card-based operating system. The only purpose of this thing was to act as a portal to get us to the CDC6600 at the David Taylor Model Basin in Carderock, Maryland. So you needed all of that just to get there and it took all day or half a day to get started. You used card decks. I am not very neat and I dropped them half the time. You put card decks into the card reader and it would go on tape and that would be sped over the phone lines at 100 baud or something like that to Carderock. After about a week you would get back the results. It would take a week because the first 10 times they would find a card out of order. That's the computer support we had.

Three or four years later we also got a PDP11, although memory was very limited. If you put in the FORTRAN compiler you had 10 words left to do the program. FORTRAN was not the ideal thing for working on a PDP.

Luckily, with our Fourier transforms, it was mainly a theoretical thing. We did a whole bunch of calculations to compare our transforms with other people's transforms and for that we needed a computer. Most of the work was theoretical, however. I had to construct this algorithm, describe how to construct it and explain why it was better or worse. We then did comparisons with some analytical functions that approximated electromagnetic pulse. That was, I think, the first thing I did there.

Steve Stephens: Was there very much of a culture shock moving from the Northeast to what was then considered the South?

Al Brandstein: Yes, everything in the neighborhood. How we came to love this area is a totally different story. In those days, college prep courses were not allowed in Woodbridge high schools. Advanced placement was not allowed and when my son got to high school age I inadvertently became head of the Parent Teacher Association at the local high school. Being naïve, I went to the first meeting and had to leave early so I signed up for the library committee. I was the only one signed up for anything and I couldn't get rid of it so I was President for 12 years or so. But that gave me a lot of influence and we feel that was part of turning around the county.

Steve Stephens: Prince William County?

Al Brandstein: Yes, it's Prince William County and the high school is Woodbridge High School. In part the influence is because my son is a little different. He completed all the work for a master's in mathematics while he was still in high school. So, all in all, there wasn't that much of a culture shock. Within the environment at the Harry Diamond Lab, for the four physicists and me there was nothing for us to do except what we felt like doing. Actually, that's not really correct.

Steve Stephens: What happened to the lab?

Al Brandstein: The neighbors complained about the pulses being set off there, but actually I think it's because people wanted the land for something else. My boss said worrying about EMP is like worrying about the outbreak of psoriasis on a patient that's dying of cancer.

Steve Stephens: How long were you at the Harry Diamond Labs?

Al Brandstein: From 1972 to 1980. I'll tell you a story about how I left. In the mornings, we would have public affairs talks. Someone would go over what was in the newspaper and we'd have a book review. To keep busy, we would try to learn a computer language a week. Now these were very smart people. Then we came across GPSS, General Purpose Simulation System and it looked like that could be used to do things that might be beneficial to the lab, just in case somebody would check on us and wonder why we were there. So we learned GPSS and then we developed models of communication systems, specifically the nuclear release chain in Europe, AUTOVON and AUTODIN2. [Note: Developed in the 1960s, AUTOVON (Automatic Voice Network) was designed to carry DoD mission-critical and administrative voice traffic. AUTODIN (Automatic Digital Network) was also developed in the mid-1960s and handled military record communications and communications support for special intelligence communities.]

Steve Stephens: You simulated this?

Al Brandstein: Yes. GPSS, which is still around is an ideal system for doing that. I don't think anything has improved on it. Actually, it's an agent-based modeling approach, but that's for later. Harry Diamond was a corporate lab—corporate lab meaning that they were funded by other government agencies. So we actually got in the money from the Defense Communication Agency and Defense Nuclear Agency. AUTODIN2 was a concept and I'm not sure that we were totally responsible for it, but we played a role in it never coming to be. The reason being that it would work fine—the way we modeled it—it worked fine under normal conditions, but under stress it all fell apart.

For a while, I was employed at Harry Diamond as an electronics engineer, even though I had no background for it obviously. We had developed the largest transportable EMP simulator. Transportable is really stretching it—it took 25 tractor-trailers to move it. We were going to test an AUTOVON Switch that was at Polk City, Florida, so ours was brought down there. I was the one who installed the oscilloscope and probes and I installed things in the switch. I didn't know what I was doing but it was fun. And I got to play with a flash override on the telephones. The interesting part of this was that it was going to be used for the first time. We had a bunch of colonels and generals down inside this bombproof building to commemorate the inauguration of the thing.

I got bored with the talks and went outside in time to see a tornado come along and destroy the whole apparatus!

A little bit more to the story, however. We decided there was no point in staying there, so we went to Tampa for lunch. Meanwhile, my wife got a call that there's been a tornado and no sign of her husband. She calls the state police and National Guard and everybody is in a panic. Just incidentally I called from lunch to tell her I was there. Now the story of why I left.

Harry Diamond Laboratories decided that salaries were too high. Being a government lab, they did something, I don't know if they still can do it, but it's something called, ''Man in the job-jobs.'' This meant that you got a permanent grade of say, GS11—I think I was about a 13 at the time. They then brought in a panel that evaluated you depending on how productive you'd been over the last few years. That determined your salary for the next few years.

Being a typical bureaucracy, we had to close down the place for six months and fill out the paperwork. They spent an inordinate amount of money bringing in those experts from outside.

Fortunately for me, on the panel there were two people in my field in math. I was still publishing some papers on that stuff. So they evaluated me between 16 and 17. If it had been a different group of evaluators I would have been rated a 9. This raised my consciousness about myself. Meanwhile the lab discovered that, instead of reducing costs, ''Man in the job-jobs'' were going to raise costs.

The same thing happened with the physicists in my group. So we all left as soon as we could. I saw an ad in the *Potomac News*, that's the Prince William newspaper, for the job down in Quantico. It had the words ''operational analysis'' and I thought that it had to do with my kind of analysis. By the way, in the course of working at Harry Diamond, I became involved with the Military Operations Research Society (MORS). That's where I heard about operations research (OR). Except for the last two years, I've been to every MORS Symposium and plenary session since 1972.

Steve Stephens: Your association with MORS began in Harry Diamond Labs?

Al Brandstein: I felt the computer simulations we did were somehow related to operations research.

Steve Stephens: How did you come to join MORS? Did you pick up a copy of *PHALANX*?

Al Brandstein: No, it was a way to get out of town. Somebody in the office had heard of this society and that they had these meetings. MORS was meeting twice a year then. So I was going to MORS Symposia. I could always give some sort of paper or other.

Steve Stephens: At that time, if somebody from the *Washington Post* or *New York Times* interviewed you, would you describe yourself as an operations research analyst?

Al Brandstein: No, I didn't take on that appellation. Just like you were an officer and a gentleman by act of Congress; that was your appellation. I didn't take that on until I got to the Marine Corps.

Steve Stephens: What happened when you arrived at Quantico?

Al Brandstein: It was then called the Systems Analysis Branch. Lieutenant Colonel John Short had just started it and it somehow had moved down from headquarters. There were a couple of majors and me. We were the analytic arm of the Marine Corps. We had no idea what it meant but at least now we're in the realm of analysis. John was a cost analyst and we had one major who was an OR analyst.

Steve Stephens: So the Marine Corps had established an operations research military occupational specialty at that time?

Al Brandstein: To the best of my knowledge. I didn't know much about military occupational specialties and things like that. They set up this branch; there were two or three people in it. And the first thing I did was evaluate the ARMVAL (Advanced Anti-armor Vehicle Evaluation). Do you know what that is?

Steve Stephens: Yes, most definitely, out in California at Fort Hunter Liggett. Dick Wiles was out in California at that time and was involved in ARMVAL. He was a Colonel in the Army then. [Note: COL Richard I. Wiles, FS, is MORS Executive Vice President Emeritus.]

Al Brandstein: General Al Gray, at this time he was in command of Fleet Marine Forces, Atlantic. General Gray wanted these light armored vehicles. He liked to scoot around the battlefield. He felt these would be better than tanks for the Marine Corps and had his mind set on replacing them. So we set up this experiment out in California with surrogates in the role of light armored vehicles. I don't think there's been an experiment the Marine Corps has been involved with even now that was as sophisticated as this. It was completely instrumented with lasers simulating vehicles firing at each other. [Note: General Alfred Gray went on to become the 29th Commandant of the Marine Corps.]

Steve Stephens: I was in charge of the data collectors at Fort Hunter Liggett during the ARMVAL test.

Al Brandstein: Well then it is a small world. I'm sort of proud of the analysis. When you look at the results, it obviously seems like the test effort had been set up with the intent to make the light armored vehicles come out better. It was clear when you looked at the design. When you looked at the data, that was not the case. The good guys lost. It fell upon me to figure out why.

Of course there were all these Latin squares and complicated designs of experiment. Everything was as sophisticated as you can get. The clue came as I was talking to somebody who

was out at the experiment. He mentioned that it rained the weekend before the Marine Corps Birthday. It turned out that more of the tests of one sort were done after the rain. The rain, however, was not recorded because it was on a weekend. The dust had settled and as a result the lower sensors on the tanks would respond to the lasers. Now when you took that into account—what I did was to go back to the video tapes and visually counted up each hit. When you did that right, the good guys won. That took six months of agony.

Steve Stephens: Now the light armored vehicle is mobilized around the world in Marine Corps units.

Al Brandstein: Maybe if I hadn't fixed it, who knows. Two or three independent organizations came to the opposite conclusion.

In those days it became quite clear that my role down at Quantico was to be something I call ''defensive analysis.'' The Marine Corps could not afford, nor did we want, those huge models that the other services had, such as TACWAR and THUNDER. Furthermore, it was the impression of some, including myself, that sometimes the purpose of the models was first to come up with the decision and then run the models to support that decision.

Defensive analysis, as I use the term, is to protect the Marine Corps from such shenanigans. That part, I think, was about the only thing I was ever reasonably successful at.

I used to go around giving these talks that you could learn a lot by taking a look at how models were used. There are two things I want to address. The role of models in analysis and the verification, validation, and accreditation (VV&A) process.

I could not understand how people could take the theory that a set of Lanchester equations could provide answers to questions being asked of combat models. You have these differential equations—there is nothing wrong with the equations, by the way. Yet we use them to draw conclusions about what sort of equipment to buy or what sort of force structure to build.

First of all, with these equations we have no idea what the equations are actually representing, whether they have some sort of meaning. They are just broad differential equations. Do they measure some sort of central tendency? How do you handle the outliers? How do you handle the human decisions? The tendency as the years went by was to make the simulations more and more detailed. In my mind that made them less and less useful. The reason being that you couldn't possibly run it enough times even if you could simulate everything which nobody knew how to do.

This problem with the differential equations model, I thought, was emphasized when MORS came out with the *PHALANX* series of papers on nonmonotonicity. Maybe I remember them because they were along my line of thinking. So I used to give talks about these defects and the fact that often the answer was obtained and then the models were run to substantiate the answer. We're supposed to have some ethics. I had two choices; one was to burn my union card, and the other was to try to fix it. And I spent the rest of my career, such as it was, in trying to come up with ways of fixing this nightmare—make models appropriate for the questions at hand.

I wondered why OR—I have been wondering this since 1980—why OR worked in World War II and it doesn't seem to have worked since. And I still questioned until I read a book called *Hunting U-Boats in the Bay of Biscayne*. It turns out that OR, in that instance, was a cover for cracking the enigma machine. So OR really didn't work then either but it was so classified that nobody knew about it and McNamara came along and institutionalized it. One of the greatest frauds in OR is cost and operational effectiveness analyses (COEAs).

Steve Stephens: Why are the COEAs a fraud?

Al Brandstein: Perhaps ''fraud'' is too strong a word because many analysts were well intended. But we had no way of finding out what the effectiveness was in any meaningful manner, in my mind. You get samples of what this effectiveness is, but you don't get the effectiveness. The effectiveness is going to be based on who is using it how, what the times were, when this tree is here or there. By the way, simulations by this time were taking that into account. If we move this tree from this location over five feet, it makes the model sensitive to it. Now if you go to buy equipment based on that and you don't know where that tree is, or even what country you're going to be in, how do you use models?

They were nice models; they were just not suitable to answer the questions that I was interested in.

Somehow, as I rose up through ranks, I got thrown into these briar patches. Because I was the only civilian doing this stuff for many years in the Marine Corps, I became the representative in places like the Analysis Council.

Steve Stephens: While you were doing this, how was your relationship with the Center for Naval Analyses (CNA) Marine Corps Operations Analysis Group (MCOAG)?

Al Brandstein: My feeling was that they felt above the fray. If there was no sophisticated academic approach to a question, they would not approach it. For some the attitude was: I'm from CNA so I know better than you. I became very friendly with one of them after I convinced him to leave MCOAG and go someplace else. They had some hammers and they tried to convert the world into nails so they could use them. I fought them tooth and nail and I was on some sort of board that oversaw them—but that didn't help too much. There was lots of political influence on their side.

Another interesting part of it was the combat models; I think they had their place. But combat models were considered beneath the dignity of CNA. I won't mention any names, but several people have left CNA because of that. So my relationship is not very good, but on the other hand they were free help. The Department of the Navy gave us some money; if we didn't use CNA we wouldn't have the money. I have a lot of respect for some of the people there, Dr. George Akst, for instance.

A thing you may be most interested in is the MV-22. That is an example of this defensive analysis. All the analysts in the Office of the Secretary of Defense Program Analysis and Evaluation (PA&E) were dead set against the MV-22. They ran TACWAR and it showed that the MV-22 made no contribution whatsoever. Meanwhile, we had lots of friends in Congress who were eager to pursue this. So I needed to come up with something that the PA&E bunch could not find fault with. I didn't have to show that the MV-22 came out better all the time, I just needed to find one instance of where, if you had the MV-22 you succeeded and if you didn't have it you failed. So we did it. It was with Colonel Ted Smyth. We called it the Root Canal, that's his term. Remember this was in the early 1990s.

So we came up with the following technique that became—although I didn't know at the time—the foundation for the stuff I was doing later. I wanted to use a combination of war games and closed form models to take advantage of the best features of each while ignoring the worst. So we had a model almost identical to JANUS—from the same people who did JANUS. I had something like 30 odd terminals, where in those days you maybe got two to work at once and 30 odd ladies—that was part of the "root canal," I'd have all these personnel problems and I am not equipped for personnel problems.

Colonel Gary Anderson had the role of the Marine Expeditionary Force (MEF) Commander. And we'd run the war game until we got it to a decision point. We'd take the decisions that came out of that, put them into decision tables in the closed form model, run that until it got to another decision point, take it back and run it in the war game.

And we came up with a situation where if you had the MV-22 you won hands down and if you didn't have it, you lost. That was just the one instance though. It turned out because you could close a gap and trap two armies. This had to be done totally in the open. Throughout the process, I had observers from OSD, the Army and the Air Force.

So we did it and the Assistant Secretary of the Navy (Research, Development, and Acquisition) [ASN RD&A] Ms. Nora Slatkin—after we completed all this—said, "isn't it ironic that the whole future of the Marine Corps depends on a town nobody heard of." But that's how it worked. That's what we had to do at this point. That's an example of what I was talking about in terms of defensive analysis. If PA&E had model runs during their internal analyses that showed that there was value in the MV-22, they probably would have never told us about them.

Steve Stephens: What support was provided and how did it come about that you provided the support from Studies and Analysis in the early 1990s to the Desert Storm operation?

Al Brandstein: How it came about was that Quantico wanted to participate as best they could and at the very start of Desert Storm, and along came Marty Steele.

Steve Stephens: General Martin Steele. He was a colonel then, wasn't he?

Al Brandstein: He was a colonel. He arrived within two or three days of the invasion of Kuwait. Not knowing any better, he enlisted my help. If he had been around for a while he wouldn't have. We were in charge of working out a plan of what would be happening about six months from that point. And that's really the start. Colonel Mark Cancian arrived. He had studied what the Naval Postgraduate School had done in the 1973 war. That was when they sent people out poking pencils in the holes in tanks and coming up with a cardioid distribution. Marty Steele and Mark Cancian wanted to do that same sort of thing. So we organized teams to go over there. It was hard to get them into the theater, at least initially. And we also had started when General Gray was there—the lessons learned system.

Going back a few years, General Gray was the Commandant of the Marine Corps. And we, back in Quantico, had lots of commitments to him that we met except for the lessons learned system he had asked for.

We pretty much ignored the lessons learned system, hoping the Commandant would forget about it. We didn't know what a lessons learned system was. We did not know how to go about getting one and we certainly didn't have any funding for it, even if we knew what it was. But he called, very irately one day and wanted to know where his lessons learned system was. So we took the next guy who came through the door—of those coming through the door, we took the one with the highest GCT (General Competency Test) score. This happened to be Major Gary Brisbois. We said, "The Commandant wants this lessons learned system. Get one for him. Unfortunately, we don't have any assets or money and we don't know what one is. But do it."

And Gary did it. Not only did he do that, which became the sample for all the other Services' lessons learned systems, he also developed a remedial action program. So then along comes Desert Shield and Storm and this gave us the entry into the theatre because we sent teams over to teach people how to use the lessons learned system and then together with Mark Cancian's initial efforts, we sent people over to collect data. They wanted a sophisticated name for it and unfortunately the best I could think of was MCOAAG, Marine Corps Operations Analysis and Assessment Group. [Note: MCOAG was a CNA organization. MCOAAG was a Marine Corps temporary organization.]

We then had about 250 people in Studies and Analysis with the Reserves that had been called up. We hot seated it around the clock, running a 24-hour operation. In addition to having teams over there, we had support back here. In part logistics consisted of sending Girl Scout cookies over. We had two airplanes at our disposal and we would trade riding in the airplanes and Girl Scout cookies for data. It worked.

Steve Stephens: What kind of airplanes did you have?

Al Brandstein: C-12. Small ones, not the big ones. One reason we were so effective is because we had reserves who, as civilians, worked in the State Department. So they knew all the ropes. Whom to call, what to do, and we managed everything with two telephones in the office.

The leader of the team over there was Colonel Cliff Stanley. Gary Brisbois had, in the interim, retired from the Marine Corps. So he was hired back as a contractor, and he worked for Potomac Research, or some company like that, to go through the data, organize it, and define lessons learned. That was our involvement.

I was in charge of the Marine Corps report to Congress on this that got sanitized a little bit. I found it interesting because we had to make deals. We knew things about some of the Services we weren't sure Congress would appreciate and other Services knew things about us that we were sure Congress wouldn't appreciate and we did a lot of horse trading to make sure that neither side was terribly embarrassed.

Subsequent to this came all the horrors from the General Accounting Office, the *Washington Post*, Greenpeace, et al. They all wanted to know what was in the lessons learned system from the war.

Steve Stephens: I think at the time I heard something about a fight over freedom of information?

Al Brandstein: Yes, there were Freedom of Information Act inquiries and we said that this

was predecisional data, was not subject to the Freedom of Information Act and this went back and forth. If I had anything that these people were looking for, I would have given it to them immediately but I didn't have anything and they didn't believe it.

Steve Stephens: How did Project Albert start?

Al Brandstein: My recollection is not the same as Dr. Gary Horne's. I don't know which one's right. I'm just going to tell you what I recall. General Van Riper, before coming to Quantico, had been exposed to something he called ''new sciences.'' He was very enthused about it. So he sent me off to go to the Santa Fe Institute where they were doing that sort of thing.

I went off kicking and screaming for two reasons: one, I had just read the *Scientific American* article on the Institute; and two, I was, as a mathematician and OR analyst, basically a reductionist, that is breaking things down to pieces, and this was anathema to that. I didn't have much choice.

So I went off there and I felt most of the stuff they were doing was pedantic nonsense. Nevertheless, there were some valuable nuggets. They were studying systems that were not amenable to traditional analysis and they seemed to have some approaches that might make a dent in it. So I became a semi-enthusiast, especially since General Van Riper kept hitting me over the head with it. And that's how we got involved with complexity and that sort of thing.

Then, General Van Riper went around giving talks haranguing against the mechanistic world of Isaac Newton. One day he couldn't make a talk, so I went up to a think tank in Washington, I think it was CIS (Center for International Studies). I talked a little bit about what we were up to and complexity and maybe my usual topic about why traditional analysis doesn't work on most problems.

A gentlemen from CIS came up to me and said he was friendly with Senator Inouye's principal staffer and was pretty sure that if we could find some way to legitimately use the high-performance computers in Maui, the Senator would see to it that we got funded for it and there was enough left over to do our research.

So we sat down, and this is the part where my memory and Gary's are different—but I'm giving you my side and I can't say for sure that it's correct. So we sat down there and came up with this eight-year plan and budget and with goals and milestones and all this done in a half hour. That budget has come through every year just the way we described it and the milestones have been met, actually. So that's the origin of Project Albert.

Then back to Isaac Newton. About 10% of CNA's time was devoted to the Marine Corps. Dr. George Akst, who worked there at the time, put us in contact with a new PhD they had, Andy Ilachinski, who had a PhD in something like this.

So we asked him to try to create one of the models like they were using at the Santa Fe Institute, cellular automata models, and make one that could apply to warfare. The result was ISAAC (Irreducible Semi-Autonomous Adaptive Combat), the first of these models. It was named ISAAC partly because it was an acronym but mainly because General Van Riper didn't like Isaac Newton's mechanistic world.

Some of the people at CNA are a little bit different. Usually the good guys were blue and the bad guys were red. Andy reversed that in ISAAC, so the good guys were red and the bad guys were blue. That was, I think, because of Andy's Slovak heritage. We quickly changed that to make the good guys blue and the bad guys red. Anyway, this became the first of these things that was a proof of concept of where the cellular automata that were moved could be used to study some of the emergent issues in warfare. So that was the first of these models and sort of perpetuated itself.

Gary Horne who was then at CNA eventually moved to MITRE. And at the time, Gary Brisbois was running the MITRE office in Woodbridge, near Quantico, and he provided a very fertile environment for fostering this stuff.

Steve Stephens: You've been accused of naming all your models after dead mathematicians.

Al Brandstein: That's right. I've tried to. There's Archimedes, which was technically a success but a failure in terms of utility. Because I wanted a fuzzy logic approach and we got the fuzzy calculus in there and it's a rigorous calculus. Our developers, however, were physicists and couldn't relate to mere mortals.

Then we had Pythagoras, which gets enough of the fuzzy logic in there to make it useful but is

also much more utilitarian and easier to use. And there's Socrates. I'm not sure he's a mathematician, well, you could say he was.

And what else did we have? Gauss. Gauss is not a model but it was a way of trying to convert things from one level of resolution to another one, more or less automatically. And then Albert is the name; Project Albert comes from Albert Einstein. Now that we had things like ISAAC, the natural question is, if you had such a thing what in the world do you do with it? The modeling is the trivial part. It's how in the world do you use that to guide decision-making. And the intellectual successor of Isaac Newton was Albert Einstein. Hence the name.

Steve Stephens: Could you say a few words about the process of distillation?

Al Brandstein: It fits into a larger context. I have harangued against the VV&A process that's used in most combat models. That is, you have volumes full of information about algorithms, and then you have volumes about how they're put into code; and the result of those two is supposed to support accreditation. In my mind, accreditation is a decision maker saying, ''Yes this model is appropriate to use to answer this question.'' Unless you have decision makers who are far smarter than I—and there are some, especially some generals—but the normal decision maker is not.

Verification and validation contribute nothing to the decision maker's ability to assess whether this is the right model to use for deciding the future of the Marine Corps. The idea behind distillations was to start out with accreditation first. What does this guy or lady think is important about the situation? Attempting to distill that into as simple a format as possible, have that person verify that, yes, we are reflecting his thoughts and, yes, when I see something unexpected coming out of there it's not an anomaly of the model but something that really should have happened—my intuition was not sufficient at the time, but now I've learned.

So that's where I see the role of accreditation and distillation are two different facets of the same concept. I also see distillation as a means of coming up with tools to help accredit more sophisticated models when the need arises. I see that things like JWARS (Joint Warfare System) could be accredited by distilling what's in there. Making sure that the people who have some experience with this stuff see that the interactions are the way they're supposed to be and then let JWARS worry about the details.

Steve Stephens: But if that's true, when you put them all together will the final data still give the proper expected answers?

Al Brandstein: You get a choice. If you are using an unaccredited model, a model that you can't understand, you should have very little confidence that the answers are right. If you do this combination of stuff at least you have some confidence that when I do JWARS for the details, or whatever model, that it's roughly reflecting what it should have been.

The other option is you go through, you bring in some differential equations and some line of sight calculations to the general. That doesn't help him any in accrediting the thing, or he could ask me. Now why in the world would I be involved in accrediting by saying, ''Yes, this model is appropriate for determining the future of the Marine Corps.''

Steve Stephens: I have been involved in many similar discussions and it has been stated that the type of modeling to do has come to a watershed.

Al Brandstein: A watershed good or bad?

Steve Stephens: A watershed inasmuch as we've done as much as we can with end-to-end campaign-level simulations, and we've got to do something else. Do you agree with that and if you do what else should be done?

Al Brandstein: Oh, definitely. You have to do something else. I harken back and my inspiration for this is a National Academy of Sciences report, ''Making the Nation Safer 2004.'' In there it talks about complex systems and what the role of modeling is with respect to conflicts and complex systems. They may have a technical definition of it, but a complex system, in my mind, is anything where nonlinearities can occur. People are involved in some sort of decision making in there. These people can sometimes make mistakes or be geniuses and there is nonlinearity and the co-evolution. That is, very rarely will people make decisions against an adversary without taking into account what they think the adversary is thinking.

Now all of those are major components of what I think happens in warfare. Unless you

can take them into account, you're remiss. The old approach was to put more and more details into modeling. That's great but I think counterproductive—depending on what the purpose is. If the purpose is to decide on force structure or whether one tactic or strategy is better than another one, I think it's going the wrong direction. Because if they're sensitive to the location of a tree or a rock or the name of the third lance corporal in the fifth squad, then the things they are sensitive to vary over such a large range that it becomes impossible given the age of the universe to sample in enough detail to determine whether we should have four divisions or five divisions or whether the Army should be eliminated or not. They may be good for things. If you want to get a sample of what could possibly have happened, you need a model like this.

Now let's go back to situations where there's co-evolution and nonlinearities and that sort of thing. What does it mean to do analysis on those? That's where the National Academy of Science helps out. That I may have played some role in helping them help it out but that's neither here nor there. They said for systems like that, it is not appropriate to make predictions. What is appropriate is to look for processes and determine what processes could have led to an outcome. And that's exactly what the kind of modeling I'm doing tends to contribute. It looks at processes.

I'm doing things now for the Border Patrol and we see wide ranges in outcomes and then we ask ourselves why that happened. We go back and look at the models and see—we keep the random number generator—and watch what happens. Remember the models we're using are credible in that I have gotten together with the people in the Border Patrol and understand Border Patrol and I am representing this correctly; after we look at it, could such and such happen? My rules for accreditation should be just two simple ones. Is anything that came out of that, any result of the model, impossible to have happened? And number two, can you think of an event that the model couldn't recreate? Statistics seems to fall apart with this stuff and maybe it's because in my naiveté or lack of knowledge about statistics, I don't know how to sample. If you're going to make predictions, you're going to have to come up with some samples.

What we can do is to explore which processes occur, what kind of things can happen. This also leads to my definition of command and control, what the appropriate use of command and control is. And then one of the things the current models are using—well I just realized this a couple of days ago—are actually good at that. The purpose of command and control is to recognize when things are not going as anticipated. Recognize not going the way you want them and then take the appropriate action to fix it. These models, and by looking at processes, can show when things are going bad and then allow you to take some actions and see which, if any, of these could be beneficial or make things worse.

That's simple and you can pick up a guy in MANA and put him down over here and see if that makes a difference. I am not necessarily proposing that the data farming is the be all and end all. It is useful for identifying certain regions, but I think you also need to take this approach, once you see something happening is there some way you can interpose command and control to cause it not to happen the way it's going to—that's my view of command and control. Fortunately, nowadays I get to work on problems where there is no modeling infrastructure. In DoD you have billions of dollars invested in all these glorious models. They are probably good for some things. I'm not sure what, but I'm sure there are uses for them. JWARS, TACWAR, JSIMS—unfortunately went away, and that sort of thing. The Border Patrol has nothing. So it's a fertile ground for exploring and understanding what's going on and to help out the decision maker.

Steve Stephens: Two questions—why use agent-based models if you can't validate them, and why use traditional models if you can't accredit them?

Al Brandstein: I have spent the last twenty years trying to resolve this dichotomy. That is what Operational Synthesis is all about: merging the various approaches so as to arrive at meaningful answers to questions. Fortunately, MITRE has encouraged the refinement of this process as well as the application to some important, non-DoD questions.

Steve Stephens: Do you find yourself working now almost exclusively outside of DoD?

Al Brandstein: Yes. That's mainly because I'm in an organization that works entirely outside of DoD. There are two reasons for it. When I went to work at MITRE, I did not want to be involved with any funding or influence that could be traced back in any way to Project Albert. That meant getting out of DoD. But I'm in such an organization, my primary things nowadays are problems for the Border Patrol, Center for Disease Control—there they have a lot of models but they don't know how to use the models to support the right decisions and I'm trying to fix that. And the Coast Guard—I did some reviewing of what they're modeling regularly and I'm advocating, though they haven't approved it yet, that we use this agent-based approach to Border Patrol to expand that to protecting all the nation's boundaries.

Steve Stephens: Sounds like it fits right into homeland defense.

Al Brandstein: Oh, yes.

Steve Stephens: What have you found to be the differences between operations research within DoD and operations research outside DoD?

Al Brandstein: I hesitate to say. In the Department of Defense, operations research is used to justify decisions that have already been made. Outside, they actually think that it might be useful to some degree. And that's being somewhat negative, but I think more often than not, that's the case. Kabuki dance comes to mind.

Steve Stephens: Kabuki dance?

Al Brandstein: Yes, in DoD.

Steve Stephens: I don't follow that.

Al Brandstein: The more important the decision is, it's always been my thought—for minor decisions OR works great. The more important the decision is, the less a role that OR's going to play in that decision. And just think of any of the major decisions that have been made within the Defense Department, the Joint Staff, or whatever, in the last 10, 20 years. More important—take net centric warfare for instance. There's no analysis—maybe it's a great concept, maybe it's not. After the concept they came along and started doing modeling stuff. You name it, the higher the level military decision was, the less likely that OR plays a role. You want to know something about the logistics trade and how they get things quicker or faster from one place to another, then you use OR. I shouldn't be so cynical.

Steve Stephens: I have heard that one primary difference is the fact that within the Department of Defense you don't have the profit there. You don't have that bottom line.

Al Brandstein: I'm working for other government agencies. The for-profit world was not one that I could fit into. I tried it for a while.

Steve Stephens: So within the government but not within DoD.

Al Brandstein: Exactly. The part of MITRE that I worked for—Center for Enterprise Modernization—only works for government agencies.

Steve Stephens: From your viewpoint what is the state—state of the union as it were—of the operations research profession in the United States?

Al Brandstein: In the United States, DoD is becoming more and more stylized. Outside of DoD it seems to be prospering. For instance, look at the FAA or you look at electrical distribution and you look at the topics that we are currently involved with, I see at least the stature of OR increasing in areas and parts of the government outside DoD. Now this is again a biased, cynical view. I've been too much involved in making sausage within the DoD framework.

You see it also when you go to professional meetings. Lots of people in OR. It's a blooming field. Less and less of them are going to DoD OR. And that's something to worry about.

Steve Stephens: The multidisciplinary approach—the hallmark of the early days –of OR and the curricular approach where we have an OR curriculum. What are the advantages and disadvantages of each and which direction do you think we should be going?

Al Brandstein: Definitely multidisciplinary. If you have enough background and especially math and it used to be in physics though I don't think you need physics so much anymore and here I'll go off in a tangent again. OR modeling often, lately, and maybe, over the last couple of years, has suffered from physics envy. You have to have physics around. You've got to get the physics right. The physics—if you got the physics wrong it's bad; you'll never get it V&V'd.

But most of the things that are happening are not physics based. Physics can tell whether

a bullet will strike a target but has little to do with the actual decision to fire. Morale, on the other hand is one of the things that are most important. You need math. That's clear. And you need to have a liberal arts education perhaps in order to think.

You may have one or two OR courses, but if you have the math you can pick up the rest. If you don't have the sociology background or human psychology background or at least know what's going on in those fields, it's much more difficult to pick up. That's the way our OR forefathers were.

Steve Stephens: What would you offer as advice to a young person entering DoD operations research either wearing a uniform or not wearing a uniform?

Al Brandstein: I'd say get a PhD in something other than operations research—that, by the way, seems to be CNA style. A PhD's not good for anything except it's a guarantee or semiguarantee that you can do some thinking. I think that's what CNA is about. They hire people with proven thinking abilities. You're probably better off not having the OR background and then learning it on the job.

Because of the famous story, that is, three guys go in for a job interview and it's only one question. How much is one plus one? The mathematician comes in and his answer is ''Two.'' Engineer—''To how many significant digits would you like the answer?'' And the OR person goes on in, closes the door, closes the blinds, goes up and whispers, ''How much would you like it to be?'' Now that's more and more becoming the reputation of OR within the defense community. We need to change that reputation.

Remember, we go back to defensive analysis. I thought, more than half the time, that the models used were irrelevant. If you're clever enough you can come up with a scenario and tweak the algorithms in the model to give you the answer you want. And you have to be; if you're cleverer you can do it so that other people don't recognize it, and that too often is the way analysis within the DoD works.

I've advocated for Quadrennial Defense Reviews (QDRs) in the past and they, of course, laughed me out of the building—that the Marine Corps do the analysis of where the Air Force should be going. The Navy does the Army's and the Army does the Marine Corps'. Also what I've advocated for mission area analysis, you want infantry say done by the artillery community and the artillery folks or maybe logistics people do the role of what infantry should do. Then you get the flavor of what you want that service, that particular part of the service to do, presuming everybody's patriots. We're not going to go too far off. I need artillery to do this, this and this for me. The infantry or the logistics people are saying that. They laughed me out of the building. And one of the things I got most laughed at, was when I used to be on the board of JWARS.

I was on the analysis counsel and the JWARS steering committee and the executive—you name it, I was on it. Namely because I was, at least certain parts of the time, if it had more than one syllable in it, I was directed to do it. I was just the only one around. Not that I had any capabilities. So what I advocated for JWARS was the following. Remove all classifications, and then distribute it as widely as possible throughout the world. If the U.S. is really as good as we think we are—let them do the analysis and prove to themselves that they can't win a war. The only ones left are going to be the lunatics, but you'd have that anyway.

But then we got the Marine officers who came out of Naval Postgraduate School who did, say, their thesis on Markov chains or some sort. They divided questions into two categories: Markov chains or insolvable. What I've advocated in schools and I think it's something that should be taught is something I've named, for want of a better name, meta-analysis. This would be a series of case studies on what were the various analytical problems in the defense community, what was the approach used, why they picked that approach, what was wrong with it and what would have happened if they would have used a different approach.

I think that should be a required course of theory. I tried to get it instituted at the Postgraduate School and they, at the time, said they didn't have the staff to teach it. So I offered to go out and get a couple of seminars and have other people do them as well.

You need to have a broad background and various techniques rather than an in-depth knowledge of any one. You can always look them up in the book of rules.