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Saul I. Gass Interview (MORS)

Gass, Saul I.

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Military Operations Research Society (MORS) Oral History Project Interview of Saul I. Gass

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MILITARY OPERATIONS RESEARCH HERITAGE ARTICLE

INTRODUCTION

Dr. Saul I. Gass is currently Professor Emeritus at the Robert H. Smith School of Business, University of Maryland. He was the 25th President of the Operations Research Society of America (ORSA) in 1976. Dr. Gass received the Military Applications Society's Jacinto Steinhardt Memorial Award for outstanding contributions to military operations research in 1996. As expressed by Peter Horner in the December 2001 issue of *OR/MS Today*, "Gass didn't, for example, invent linear programming. He just learned it from those who did, people like George Dantzig, and then Gass went out and wrote the first textbook on the subject. His text, *Linear Programming* now in its fifth edition, has introduced LP and OR to literally thousands of students since it was first published in 1958."

By coincidence, Gene Visco, FS, was Saul's classmate in 1949 for "Theory of Equations and Finite Differences" (at Boston University), and Gene was also Saul's student for Linear Programming in 1957 (at the U. S. Department of Agriculture Graduate School).

MORS ORAL HISTORY

INTERVIEW WITH SAUL GASS
March 10, 2005
Bethesda, Maryland
GENE VISCO, FS, and BOB SHELDON, FS, INTERVIEWERS

BOB SHELDON: This is the 10th of March, 2005 and we're in Bethesda, Maryland to interview Saul Gass. First of all, give us your parents' names and tell us what kind of influence they had on your career.

SAUL GASS: My mother's name is Bertha, her maiden name was Kotker; my father's name is Louis, last name Gass, although its Russian equivalent was more like Hoos. They both emigrated from Russia in their early teens around 1914. I know exactly when my mother came over as my son Ron located her ship's manifest (Cunard Line SS Laconia) in the National Archives in Washington. The ship sailed from Liverpool on August 8, 1914 and arrived in New York City on August 16, 1914. My mother's father was already in the U.S. with her three older sisters. My mother was eleven, the oldest of the five children (two boys and three girls, one of which was my Aunt Dot who was nine months old) who traveled on the Laconia with her mother. How my grandmother, who was then 44 years old, managed to get herself and brood from Russia to Liverpool is a mystery to me. She only spoke Yiddish. The manifest noted that she had $5 in her possession when she arrived at Ellis Island. The Laconia was used by the British during WW II as a transport ship and was sunk by a U-boat on September 12, 1942 while traveling from Africa to England. My father's parents had four boys and three girls, all born in Russia. All four grandparents managed to emigrate to the US. I have always felt fortunate that I knew them.

GENE VISCO: Was it Russia or Ukraine?

SAUL GASS: My mother's town (shtetl) was in Ukraine, a town called Krasnostaw. My father never really told us what town he was born in. He would just make up some funny name like Chuppup-pupinov. My parents and relatives and my friends' parents, who were also immigrants, never talked about the old days. That was typical of their generation. Both of my parents had little formal school education, but they learned English and spoke it without an accent.

My father sold life insurance for Metropolitan Life and later Boston Mutual Life, and, for a while, was a salesman for the Prince Macaroni Company. He was also a writer and poet. He wrote a column in Yiddish for one of Boston's Jewish weekly newspapers. He also had a Yiddish radio show sponsored by Prince Macaroni. I would on occasion go to the studio with him on Sunday mornings—my first exposure to writing and speaking. My father would ensconce himself in the bathroom (we had a two-bedroom railroad-type flat) to read and time his radio script that he wrote on his Yiddish typewriter. He was a fast pick and pecker typist. My older

brother Jerry and I inherited his typing style and bought, on a weekly payment plan, an English portable typewriter for our high school reports. We paid five bucks a week until we both went into the service; my mother assumed the payments after that! My father loved to tell jokes, especially those that played on word meanings. One of his favorites was about "Beethoven's fifth movement in A-Flat because he couldn't pay the rent." I've picked up the tradition, but don't get me started! My mother kept us on the straight and narrow and, in general, I stayed out of trouble and learned to hit the books.

BOB SHELDON: Where did you go to grammar school?

SAUL GASS: My first school was the Pratt Grammar School in Chelsea, Massachusetts. I was born in Chelsea, which is a little town just across the river from Boston. I started in the first grade, as they did not have a kindergarten. As I was born in February, my mother got me into the first grade when I was five and a half years old, as she felt I was ready for it and would be a bit too old for the first grade if I waited another year. How these little things make an impact in later life! I was in the Chelsea school for a few months and then we moved into Roxbury, an area of Boston. They had kindergarten, but due to my "advanced placement" in Chelsea, I got into the first grade. This made a difference when I graduated from high school. I was a bit younger than my friends. This was an early example of the type of influence my mother had, making sure that we got the right type of education.

My school in Roxbury was the Quincy E. Dickerman Elementary School, just three blocks from my house. I believe Dickerman was a past superintendent of Boston schools. We all walked to school, in fact, we came back home for lunch. In the sixth grade I went to another school just four blocks away, the Phillips E. Brooks. Brooks was a famous Boston Episcopal pastor and wrote "O Little Town of Bethlehem." There's a statue of him in Copley Square next to Trinity Church where he was a rector; look him up the next time you are there. In the seventh grade, I went to a new junior high school, the Patrick T. Campbell.

Campbell was a widely respected former Superintendent of the Boston school department. The "Patie" Campbell School was built right next to my apartment house on an empty field where we played ball, "cops and robbers," and roasted potatoes. I could go from my first floor back porch right over the school fence into the school yard, and that's what I did on the first day the new school opened. I made sure I did that!

BOB SHELDON: You said the City of Boston school system had an elementary system that went to the sixth grade; junior high was seventh and eighth?

SAUL GASS: When I was there, junior high was seventh, eighth, and ninth; so I was at the Patrick T. Campbell for three years.

GENE VISCO: I was there (Boston), which would have been almost the same time. We had seventh and eighth, junior high, and then high school was 9, 10, 11, 12.

SAUL GASS: In Boston itself?

GENE VISCO: Yes. I did all my high school in Boston and all my schooling.

SAUL GASS: The Campbell was the last school they built in Boston for many years. It probably had the three grades due to the lack of space for freshman at the high school. It's now called the Martin Luther King, Jr. Middle School.

GENE VISCO: We lived in Roxbury, too.

SAUL GASS: The area has changed quite a bit since my time. I went through high school at Roxbury Memorial High School for Boys, and I stress the boys; our area's part of the Boston school system was not co-ed at that time. Our building was rather big, with two wings separated by a library; girls on one side, boys on the other side, and you weren't allowed into the other side unless you had a pass (the doors were guarded by school monitors). The girls started fifteen minutes earlier and got out fifteen minutes earlier. I never knew any of the young ladies from that part of the school. But high school was very influential for myself and my friends. We received a great education. The school was over a mile away; we walked, rain, shine or snow.

BOB SHELDON: When did you first discover an interest in mathematics?

SAUL GASS: In high school. I did reasonably well in junior high, but I remember getting a D for one marking period in 8th grade mathematics, proportions and stuff like that—it was a bore. In high school, my sophomore math teacher was Tom Campbell, the son of Patrick T. Campbell. Tom Campbell was also the coach for all sports: track, baseball, football, hockey, the whole thing. I did okay in math and algebra, trigonometry and geometry but never really looked at it as a career in those days; we (my friends and I) never looked at anything as a career then. I started the normal high school routine in 1940, but the attack on Pearl Harbor the next year changed future events for me and my friends quite a bit. One of the courses taught in my senior year was navigation and aeronautics, I guess with the aim of making us bombardiers or navigators. I was on the track and baseball teams.

BOB SHELDON: Was that course taught by a military person?

SAUL GASS: No, it was taught by a regular math teacher. But that's an interesting question as we had military drill from my freshman through senior years. We wore uniforms, jodhpurs and leggings. In high school, the drill instructor was Captain James Kelly, retired infantry reserve.

GENE VISCO: Tell them about the blouse.

SAUL GASS: Oh, yes, with the high collar, WW I doughboy style. I forget the type of hat we wore, but the student officers wore a cap with a visor.

GENE VISCO: I think they were overseas hats.

SAUL GASS: I did okay in military drill. I ended up as a major in my senior year. They inscribed the names of the drill officers on the gym wall. I'm sure they're not there anymore. Every year in May, Boston had a school-boy parade competition that snaked through the downtown streets by the State House. We all marched like crazy; you wanted to come in first.

GENE VISCO: They also had a drill session in the armory which was competitive and that was judged by National Guard officers; I did that my freshman year.

SAUL GASS: I must say the math courses and the military training really served me well when I went into the service. I knew how to march, use a compass, and read a map.

BOB SHELDON: Other than math in high school, were there any other science topics that interested you?

SAUL GASS: Physics. I didn't like chemistry, never did like chemistry. I thought it was too heuristic. Just physics and mathematics turned me on. I was never very good in languages, although I did take French in junior high and German in high school. I made the honor roll most of the time, so I did reasonably well. We had classical English stuff in those days.

GENE VISCO: Composition?

SAUL GASS: Composition, yes. In my senior year, my English teacher was "Pappy Doyle" who was an old timer, no nonsense guy who put it to us. I can still recite a line from Shakespeare's Julius Caesar: "You blocks, you stones, you worse than senseless things."

GENE VISCO: Did you have any employment during high school?

SAUL GASS: Yes. During high school, part of my family on my mother's side was in the catering business. My Uncle Sam owned a couple of halls where they'd have dances and weddings and things of that sort. I didn't work too often for my uncle, but I had a regular job working at the Dorchester Plaza catering hall as the check room guy during all my years in high school. It was a few miles away. I would usually walk there and back, but sometimes got a ride home at night. So I checked coats, mostly weekends, but often during the week also. Whenever we had a wedding, I would work the balcony searchlight and shine it down on the bride and groom as they entered the hall.

My mother worked as a waitress in catering halls and belonged to the waitress union, so I'm a union guy from way back. All her sisters did the same thing, as my Uncle Sam was married to my Aunt Sarah, one of my mother's five sisters (she came over on the Laconia). He owned two halls; one in Mattapan and the other right across the street from the Christian Science Church near Huntington and Massachusetts Avenues called the Ritz Plaza.

GENE VISCO: We used to live right around the corner near Symphony Hall.

SAUL GASS: One summer I worked as a spray painter painting ammunition cans. The physical setup was such that OSHA would have closed the operation down.

We used a boxed compartment with a Lazy Susan tray and an exhaust fan in the rear. I would place a can on the table, spin it about while spritzing the sealant paint inside. After the cans dried, I would dip them into a tank of water to check for leaks. The summer before that I worked for a jeweler. I would go around to a number of pawn shops and pick up watches for repair. I learned how to get about the Boston subway and streetcar system on a dime and transfers.

BOB SHELDON: What year did you graduate from high school?

SAUL GASS: I graduated in 1943. Money was tight, but my mother wanted me to go to college. We decided on Northeastern University as it was then mainly an engineering school and not too expensive. We didn't make campus visits in those days. My father's office was on Huntington Avenue, as was Northeastern University. I remember going to my father's office and he gave me $225 for the semester. Northeastern was a co-op school; you go to work six months and then six months school. But, because of the war, they decided to push people through faster and temporarily dropped the co-op program.

I started Northeastern in the summer of 1943. I was able to put in two semesters, a full year, before I joined the Army. I was on the track team; they let freshman participate as most of the upperclassmen were in the service. I wrote for the school newspaper. Nat Hentoff, who became a famous jazz critic, was editor-in-chief.

BOB SHELDON: What distance did you run?

SAUL GASS: I ran mainly 440s and relay races. I could probably do an 880 or half a mile, but those distances weren't my thing. I was on the cross-country team. We came in third at the New England collegiate meet that was run over a course in Boston's Franklin Park.

GENE VISCO: Walt Hollis was at Northeastern the same time. He was drafted into the Army about the same time you were.

SAUL GASS: I wasn't drafted; let me tell you that story. In those days, 1942 to 1944, all the services had college programs. It seemed like a good deal in that you could sign up when you were 17. When you turned 18 they wouldn't send you to basic training, they wouldn't draft you; instead, they sent you to a college. I figured that was a good idea so I decided, for some reason, to go into the Navy's program.

I went to the main Navy recruiting office with a friend. The first thing they did was give you a physical. I had a broken nose, as you can see, and I had a deviated septum. The examining doctor said that that they can't take me unless I had the deviated septum fixed. So I talked to my mother and father and they agreed to go ahead (cost about $250). I still remember the doctor banging and banging, cleaning things out. My mother told me that the surgeon asked about straightening my nose. That raised the cost a bit, so it wasn't done.

BOB SHELDON: How did you break your nose?

SAUL GASS: It happened when I was about three years old when we were living in Chelsea. I was taking a walk with my brothers and friends. There were billboards along the way that were held up with diagonal supports. I tripped over one of them and fell on my face. Bleeding, I rushed home. We were living on the first floor of a three story house that was owned by mother's parents who lived on the second floor. As my mother wasn't home, my grandmother gave me first aid by putting on a cold compress. But when you're young, you can't tell if your nose was broken. So, after I had my septum fixed, I went back to the Navy to take the physical exam. This time, the first thing they did was to give me a color blind test. Guess who's color blind?

BOB SHELDON: Which colors do you have trouble with?

SAUL GASS: Red and green. I don't know if you've ever taken a color blind test; you can find the standard Ishihara color-blind test on the Web.

GENE VISCO: What is intriguing about that is during the war with Japan we used tests developed by a Japanese researcher.

SAUL GASS: So the Navy was out. A friend and I decided to try the Air Force. The Air Force had a big recruiting office on Commonwealth Avenue just down from Boston University. The building used to be a new car dealership and had very wide and tall windows.

In those days I could rip off the written exams and I passed the Air Force's exam without any problem. Afterwards, the Air Force major took out the color blind charts. Well, I didn't do very well. The major said, "Let's go over to the light at the windows." That did not help at all. My friend went into the Air Force and spent his time in Biloxi, Mississippi. The only thing I had left was the Army college program; so I signed up.

BOB SHELDON: The Army didn't give you a color blind test?

SAUL GASS: The Army was only interested in whether you could see; no color blind test. My birthday is February 28th and when I turned 18 in 1944 I was officially a volunteer, no draftee. My service number starts with a 1, which is a volunteer number, while draftee numbers start with a 3. But, by the time I turned 18, the Army canceled its college program. I wasn't going to any school. I got a notice with a list of about 20 other guys from different New England colleges who were trying to do the same thing. It read: "Report to Fort Devens, Mass. on March 17, 1944." That's how I ended up in the U. S. Army, in the infantry, no less.

BOB SHELDON: When did you start your Army training?

SAUL GASS: I know it was March 17th, St. Patrick's Day, big deal in Boston, so you always know that.

GENE VISCO: Big parade.

SAUL GASS: I was there for two weeks and then took a train down to Camp Blanding, Florida (near Gainesville and the University of Florida). I remember passing through Washington, D.C. and then Alexandria, Virginia and seeing my first "For Colored Only" bathroom signs. I don't know exactly what date we started training, but it was over in 15 weeks. I learned how to dig foxholes and how to recognize coral snakes. And you did the final graduation 25 mile march. From high school, I knew how to march, so I was made the guidon flag bearer for my company, an acting corporal.

After basic training I had a 30-day leave. I was very fortunate not to be sent overseas as a combat replacement. Being a replacement assigned to a new outfit in Europe was a difficult thing; you did not know anyone and you had to prove yourself with battle hardened troops. Instead, I was sent to Camp Shelby, Mississippi, assigned to the 65th Division that had been activated on August 16, 1943. A number of my buddies from Camp Blanding were also sent to Camp Shelby. I was assigned to a heavy weapons company—machine guns and mortars. I was made number one machine gunner who carried the tripod on his back. I learned how to shoot, take apart and clean a water-cooled 30 caliber machine gun, and we marched. We shipped out from New York City for Europe on January 10, 1945 and sailed in a convoy to Le Havre, France. Rumor had it that we were supposed to go to England and wait for occupation, but because of the Battle of the Bulge, they wanted to move more troops in mainland Europe. We arrived at Le Havre on January 21 and were posted to Camp Lucky Strike (near St. Valery en Caux) where we lived in large canvas tents. All the camps in that area were named after cigarettes.

We stayed at Lucky Strike for a little over a month; it was very cold, of course. In early March, we moved out by train in World War I vintage 40 and 8 boxcars (they carried 40 men or 8 horses). We relieved the 26th Yankee Division on March 6 and were assigned to defend the US line along the Saar River near Saarlautern; we were part of Patton's Third Army. We stayed there until March 17, just a year after I entered the Army. On the 18th, we moved out and breached the Siegfried Line and crossed the Rhine at Mainz on March 30. In early April, the 65th Division was the U.S. Army unit closest to Berlin. We were dubbed the "Spearhead Division," but our mission was not Berlin. We hardly stopped until the war was over about seven weeks later.

We saw some military action, especially a battle for the town of Struth on April 7, 1945. The Germans were trying to retake the nearby city of Muhlhausen. In the early morning of April 26, we crossed the Danube at Regensburg

by paddling across in little boats. From there we kept moving until we stopped in Austria. My division ended up being the furthest east of any of the US units. We took Linz on May 4 and moved to the restraining line between the US and Russian troops at a little town called Enns, eight miles southeast of Linz, situated on the Enns River. We were on the west bank, with the Russians on the east. That is where I was on V-E Day, May 8, 1945. I stayed in Europe as part of the occupation army until the following April, 1946; I didn't have enough points to come home sooner.

BOB SHELDON: Did you meet any Russian soldiers?

SAUL GASS: Oh yes, they were on duty across the river (we were near a bridge that joined the shores). I always figured that the Cold War was due to me, as I had a cheap Ingersoll watch which I sold to a Russian soldier for 60 occupation dollars. We pulled guard duty at the river. We fished by shooting our guns in the water and having the sound waves kill the fish; we also fished with hand grenades. Occupation in Austria was rather easy in the sense that we had little guard duty. We didn't have any prisoner of war camps to guard. We just did our thing—it was a pleasant summer, as I remember.

BOB SHELDON: What was your military rank?

SAUL GASS: My military rank at that time was a sergeant. We were Company M of the 261st Infantry Regiment, a heavy weapons unit that had machine guns and 80 millimeter mortars.

GENE VISCO: You never got alerted for duty in Japan?

SAUL GASS: We thought we were going to redeploy to Japan. V-J Day was August 15, 1945 and my division was deactivated on August 31. We moved back into Germany to a little town called Pfaffenhoffen where we pulled guard duty. I ended up, however, being the editor of the battalion newspaper and non-commissioned Information and Education (I&E) Officer. I guess because I had a year's college. Later on I became editor of the regimental newspaper. I did that until I got enough points to come home.

BOB SHELDON: Since you spoke German, did you talk with the local nationals?

SAUL GASS: I talked with a few locals, but there wasn't too much of that. There was a non-fraternization rule in force, but it was broken quite a bit. A few years ago, I made a car trip from Hamburg to Vienna and passed through Pfaffenhoffen. I didn't recognize the town.

We never had any trouble with the locals. There were a couple of prisoner of war camps nearby. I don't remember pulling much guard duty because I had these other duties. One thing that did happen to me, as I was the I&E non-commissioned officer, was that I got a chance to go north to the Canadian Army near the German-Holland border. I spent about three weeks there in an exchange program—to see how they ran their military.

BOB SHELDON: Did you notice any differences with the Canadian Army—how they did business?

SAUL GASS: Not too much except they were a little bit more formal, I mean British. As a parting gift I was given a swagger stick as a souvenir. When we drove back south to my unit, we stopped off overnight in a strange town where our vehicle got ripped open and all our clothes taken, as well as my swagger stick.

In April, 1946, I shipped back home on a troopship out of Antwerp. My plan was to get married and return to college. During my 30-day leave prior to going to Camp Shelby in the summer of 1944, I became involved with my wife Trudy. She was a local girl who lived a few blocks from where I did. I first met her when she was 13 and I was 15. Her family moved to California in January 1945. So I had my discharge papers made out for Los Angeles. That way I could get a discounted railroad ticket across the country.

I was discharged on May 23 at Fort Devens and came home to Boston and stayed there a couple weeks. Of course, my parents thought I was too young to get married and were not very happy, especially my mother. They had met Trudy in January 1945 when I came home on a weekend pass before shipping out to Europe.

GENE VISCO: You were 19 at the time.

SAUL GASS: I was 19, right.

GENE VISCO: That's why your mother was unhappy?

SAUL GASS: Oh yes. Also, I hadn't finished college. I took the long train ride to Los Angeles the end of May. We got married on June 30, 1946. We stayed in Los Angeles for a month. Trudy had to give notice for her job as a secretary for Prudential Life Insurance Company. We took the coach train back. Meanwhile, I had re-enrolled in Northeastern University. Northeastern University went back to the cooperative plan—six months work, then six months school. When I enrolled, my class was first assigned to jobs. They sent me to a machine shop that made iron lungs. Prior to that I was a member of the 52/20 club—you got $20.00 for 52 weeks (50 cents an hour) unemployment as part of your discharge benefits.

BOB SHELDON: You were unemployed?

SAUL GASS: Unemployed until I started school later that year. Also, as a Massachusetts resident, the State gave you $200. It all helped, as we did not have much money. I was not a happy camper with the job Northeastern assigned to me. I was getting 50 cents an hour drilling and sanding metal iron lung parts, things I really didn't like to do. I just thought it was grunt work. The boss saw that I wasn't pleased with the work, so he basically fired me by telling me to go back to the university.

That evening, I remember meeting Trudy at the streetcar stop as she returned from work—she was a secretary and bookkeeper for a luggage and golf shoe (Turf-Hugger) manufacturer—and telling her I got fired. She wasn't very happy about that. I went back to Northeastern University and they were sympathetic, basically saying, "Okay, you are a veteran. We understand that you may have some difficulties getting adjusted." I was sent to another place, a yarn manufacturer in Dorchester. I went there with another student and we were both interviewed by the boss who told us, "You better be here at 6:00 in the morning." I quickly thought, "This wasn't for me."

A friend of mine had gone to Boston University's School of Education and suggested that I check it out. I did and transferred there as an education and mathematics major, with the idea that I would become a high school teacher. That worked out well in that I had the year at Northeastern, plus Boston University gave me a half a year's credit for being in the service. I started in January, 1947 and received a Bachelors in Education in June, 1949. At that time, I was really interested in mathematics. I had taken all kinds of courses. I know that Gene had gone to BU for awhile. Didn't we have a course together Gene?

GENE VISCO: Yes, you and I were talking one time about our education. I said I had done my undergraduate work at the University of Miami in Coral Gables, Florida. But in the summer of 1949 I went to BU to take a couple math courses. Saul said, "I took a couple of math courses in the summer of 1949." I said, "I took Theory of Equations and Finite Differences." And he said, "I took Finite Differences," and in those days you only had one section in the summertime. So Saul pipes up and says, "I got an A in the class." I went back and dug in my files and I discovered I got an A-minus.

SAUL GASS: No, I got an A+!

As I had taken a lot of extra math courses while taking my bachelors degree, I only had to go during the summer of 1949 to get my masters in math. I got my Bachelors in Education in June with a math major and my Masters in Mathematics at the end of August, 1949. When I look back in terms of the time spent in the service and in college, I really didn't lose much time at all. I was very fortunate, except when I got out of school there were no jobs to be had! I had decided not to become a high school teacher after my senior year student teaching at Brookline High School, the best school in Boston. The experience turned me off.

GENE VISCO: The country was in a depression at that time. I had the same experience when I graduated a few months after that; there was no work and I was doing almost the same thing. I had taken a lot of mathematics and I was going to go teach when I graduated. I got my undergraduate degree in January of 1950, a few months after you got your masters and I pumped gas for a job.

SAUL GASS: I remember writing literally 100 letters to aircraft and engineering companies, and didn't get any replies. Also, I registered with the Federal Civil Service Commission for a position as a mathematician located in either the east or west coast.

GENE VISCO: I did too.

SAUL GASS: In November 1949, I received a job offer from the U.S. Air Force as a GS7 at $3,825 a year. I was to report to Edwards Air Force Base, located north of Los Angeles in the desert near Muroc Dry Lake in the Mojave Desert. (The space shuttles have landed there a few times.) Trudy and I packed our things and took another coach train ride to Los Angeles. I thought I was going to live and work in the desert, but when I reported to Edwards, I was informed that the job was in downtown Los Angeles. My eyes lit up.

And what was I going to do? I was to join a group called the Aberdeen Bombing Mission. They were a civilian Air Force group doing bomb ballistics analysis and related data reduction. The results were sent to Aberdeen Proving Ground in Aberdeen, Maryland. Edwards Air Force Base had a bombing range over which high-altitude bombers would fly. The aircraft had a flashing strobe light on its undercarriage so that a plate camera on the ground could take successive timed images as it crossed the range. When the aircraft dropped the bomb, a signal was registered on the plate that indicated the exact time of release and relate that event to the aircraft's altitude. Cameras located at the target area would film the bomb during its final leg of its trajectory.

We would read the film and the plates on special measuring machines. At Aberdeen, they would figure out the trajectory and develop improved bombing tables. We used Monroe and Marchant calculators and I became rather adept at being a human computer. I learned a lot. I learned the need for accuracy—we always checked each others work and initialed everything we did.

BOB SHELDON: Did you go out to the test range yourself to collect the data?

SAUL GASS: No, they would send us the film and the plates.

BOB SHELDON: How large of an office did you work in?

SAUL GASS: Including myself, there were eleven of us; the boss was a woman, Grace Harris. Except for one other guy, everyone else was a woman. You have to remember that in those days the main means of doing calculations was with desk calculators and they were most often operated by women.

GENE VISCO: Do you remember what the job title was for the women running the calculators?

SAUL GASS: At the Aberdeen Bombing Mission, except for one woman, they were all college graduates and were classified as mathematicians.

GENE VISCO: Art Stein's wife worked at Aberdeen during the war, and because she had a college degree they automatically hired her to do trajectory calculations. Her job title was "Computer."

SAUL GASS: After the first year, I had a chance to visit Aberdeen to check out some new measuring equipment. I traveled with Grace Harris. It was my first commercial flight. We flew to Chicago, changed planes, and landed at Washington National Airport. We spent the night in Washington at the Willard Hotel, which is still in service. Street cars were operating on 14th and Pennsylvania Avenues at that time.

The next day we took a flight from Washington to Baltimore, a rather dumb thing to do (BWI had recently opened). We went up and then down! Why we did not take the train from Washington's Union Station is unclear, as we then took the train in Baltimore to Aberdeen. There was a train strike at that time and I recall being stuck in a tunnel in Baltimore.

We eventually got to Aberdeen and it was an interesting three weeks. Before I left, the person in charge of the bomb ballistic work, Dr. Zug, offered me a job, but I couldn't envision working and living in Aberdeen. Anyway, back in California, I wasn't really enthused with the work and where it would lead. So, after discussion with Trudy, I put my name on the Civil Service Register for mathematicians in the Washington, DC area. Soon afterwards I received a notice saying report for work at the Pentagon. I wrote back saying, "What's the job?" The reply, "Report for an interview." As they were not going to pay my way to Washington for the interview, I declined.

I figured that ruined any future job offers from Washington, so we decided to stay in Los Angeles. Then I received a telegram to report for work. I was hired, sight unseen. I had no

idea of what the work was to be, but I got a promotion to GS9 at a salary of $5,200. I figured it couldn't be all bad. I accepted.

We had a two-year-old Chevrolet and a six-month-old son, Ron. We drove from Los Angeles to Washington in five days during the first week of January 1952. We stayed with some friends who we had met in Los Angeles; they had moved to Washington the year before.

The day I reported for duty at the Pentagon, I drove up to the River Entrance and asked the guard, "Can I park here?" He replied, "Go out there" and pointed to the vast North Parking Lot. I managed to find my way to the reporting office. My new boss, Walter Jacobs, told me to take the rest of the day off to look for an apartment. Back to North Parking where I had to walk up and down a few aisles before I found my car.

BOB SHELDON: You had a clearance for this job?

SAUL GASS: No, I didn't have any clearance to start, but that came along soon afterwards. I believe I had a secret clearance for my job in L.A.

BOB SHELDON: You didn't need it for the work you were doing?

SAUL GASS: Not at first. In those days you could walk right into the Pentagon without any badges or guard clearance. That's where I joined Project SCOOP (Scientific Computation of Optimal Programs), the Air Force program that was started a few years earlier to help mechanize its plans and programs that dealt with war plans and related logistics and deployment activities. George Dantzig was Chief Mathematician, and Marshall Wood, an economist, was head of Project SCOOP.

My introduction to linear programming was being handed three of Dantzig's papers that had recently been published in a Cowles Commission for Research in Economics monograph. This publication included papers given at a 1949 conference of what is now considered to be the 0^{th} Mathematical Programming Symposium. Since I had courses in linear algebra and related topics, I could read the papers, but not necessarily understand them right away or have any idea of their implications. With these papers, I began my long association with linear programming and operations research, in general.

I worked for Walter Jacobs. Walter had a Ph.D. in statistics from George Washington University. Walter's shop, the Mathematical Formulation Branch, was responsible for modeling the Air Force's Project SCOOP problems. In those days, high-speed computers were not readily available, although the Project SCOOP office had ordered the second UNIVAC that was going to come in later that year.

BOB SHELDON: What year was that?

SAUL GASS: 1952. My work for Walter got me involved with linear programming problem formulation and their solution on computers. We had an IBM card-programmed-calculator (CPC) which we used for testing the simplex method, at least matrix inversion and related computations. The need for accurate and fast matrix inversion procedures really drove the whole field. We would run test problems and do research in terms of mathematical structures of linear programs.

The electronic computer we initially used was the SEAC, Standards Eastern Automatic Computer, at the National Bureau of Standards (NBS) located in Washington, DC. I would coordinate the runs with NBS. I would drive the problems from the Pentagon, up Rock Creek Park, a most pleasant drive, and end up at the NBS campus on Van Ness Street. At that time, NBS had a terrific staff of mathematicians, for example Alan Hoffman. They were partially sponsored by Project SCOOP. This work brought me close to the computational aspects of linear programming.

BOB SHELDON: Where was your office in the Pentagon?

SAUL GASS: We were on the 5^{th} floor and it was probably the C ring. When the UNIVAC computer was delivered in April of 1952, it was installed in the basement. They needed special raised flooring with the cables going underneath. Later, my office moved to the basement. In our group were Leon Goldstein, although not a Ph.D. he was a well-trained mathematician; Alex Orden, a Ph.D. mathematician who had worked on the Whirlwind computer at MIT; Julian Holley, a Ph.D. mathematician from Harvard; and Walter Jacobs. We also had some summer students. The year before, 1951,

the summer students were Phillip Wolfe and Thomas Saaty. Phil was a Ph.D. student of Albert Tucker at Princeton and Tom Saaty was finishing his Ph.D. from Yale. Tom returned as a summer student in 1952; we've been personal and professional friends ever since.

BOB SHELDON: Were you all civilians? Any military officers?

SAUL GASS: The people I just mentioned were all civilians, but we worked closely with many military people. There was an Air Force officer, Lt. Colonel Robert Kirby, who worked in our office at the same level as Walter Jacobs, plus many others. There were also some junior officers who had a mathematical or engineering background and spent a tour or their reserve duty with us. There were also many airmen, especially in the computer programming area, computer operators, and computer engineers.

Between the Air Force and civilian staffs, we had a very diverse group of interesting people. The Air Force had a number of civilian women, especially in the statistics and data analysis area. From my Aberdeen Bombing Mission experience, I never had problems working with or appreciating the contributions of the Project SCOOP women. It carried over to my future work at IBM and at the university where I both worked with and managed women. It was a great learning environment, both professionally and in terms of human interactions. We were all pioneers in the use of computers to solve decision problems, but we certainly didn't think of ourselves in that way.

Project SCOOP offered me a research environment not unlike one you experience at a university or scientific laboratory. I became involved in a number of then seminal problem areas. For example, Walter Jacobs posed a training of mechanics problem in which you wanted to meet the monthly requirements for trained mechanics by trading off between the number of mechanics you trained each month versus the number of trained personnel awaiting to be assigned in a replacement pool. As the requirements can fluctuate from month to month, it is inefficient to produce exactly the number required, so you attempt to smooth the training output by placing trained mechanics in a surplus pool. This is an example of conflicting objectives: smooth the training output and keep the number in surplus as small as possible while meeting the monthly requirements. The problem can be posed in a form we now call parametric programming.

You have the sum of two linear objective functions with one of them multiplied by a parameter (weight) that goes from zero to infinity. Depending on the value of the parameter, you make one objective more important than the other. The question is: How do you find a set of solutions that are optimal for different values of the parameter? And, can you use the simplex algorithm? I managed to modify the algorithm to do just that. With Tom Saaty and some help from Leon Goldstein and Alan Hoffman, this led to my first publication. The generated set of solutions are Pareto optimal solutions (efficient solutions), but such a concept was not one that I was familiar with at that time.

BOB SHELDON: What were the sizes of those programs? How many variables?

SAUL GASS: The ones we tried out by hand to prove the parametric method were certainly small. Later on, the method was recommended for coding on the UNIVAC, but I don't believe it ever was. From my perspective, I just needed a few small problems to show that the process worked OK. It was an interesting problem and was my first venture in conducting such algorithmic research.

GENE VISCO: About this time you began thinking about a doctorate?

SAUL GASS: No, getting my doctorate evolved over time. I must go back a little bit in time. I got my BS and MA degrees under the GI Bill. When you signed on for the GI Bill with the Veterans Administration, you had to state your educational objectives, which in my case was an MA. I had some good professors and advisors who thought I should pursue a Ph.D., but I couldn't do it under the GI Bill; my time was used up. When I came to work at the Pentagon, it just never crossed my mind. But I was working with all these Ph.D.'s, with George Dantzig from Berkeley.

I was married, with two kids; Ron, born in Los Angeles in 1951 and Joyce, born in Arlington in 1955. The work at the Pentagon set me on my career in operations research. But that was not planned, just an accident that happened as

I was picked off the Civil Service Register (a second time), sight unseen and lucking out. I've been very fortunate.

BOB SHELDON: How did they pick you?

SAUL GASS: Right off the Civil Service Register. I described earlier my run around with the Civil Service people and their wanting me to come to Washington for an interview without paying my expenses. About a year after I reported to work in the Pentagon, I asked Walter Jacobs about it. Walter said he was told by the Civil Service office that I wasn't coming out for an interview under such circumstances. Hearing that, he told them, "This guy must have some sense, hire him."

GENE VISCO: To expand on this, it was always traditional from the early 1940s on, that when you were in college, usually in your junior year or senior year, you took the Civil Service exam. Everybody did it, you just did it automatically. It was always thought of as something good to think about with security. I got a telegram inviting me to go to work at Dugway Proving Ground in Utah in 1950, as I was on a register as a result of what I had done during my undergraduate work.

SAUL GASS: I was lucky as I received some extra Civil Service exam points from my military service and a service-connected disability for frozen toes and a hernia that gave me 20 more points. These points and my MA degree put me up at the top of the Civil Service register.

BOB SHELDON: The frozen toes, how did that happen?

SAUL GASS: The frozen toes came about during the winter of 1945 as we marched through Germany; spending time in the cold in foxholes and pulling guard duty. It wasn't a bad case, but when I took my discharge final physical exam, the doctor said I had frozen toes and a hernia, which I think I got from lugging the machine gun tripod. Frozen toes and a hernia were worth 10 points each. The disabilities are gone now, although the VA recognizes them when they classify you for their hospital service.

GENE VISCO: You still get the extra points.

SAUL GASS: Yes. In those days, my work goal was to be a GS15 at $25,000 a year.

GENE VISCO: Well yes, a GS12 at that time was making over $7,000 a year.

SAUL GASS: Let me try and wrap up the Pentagon. I became quite involved in two new mathematical fields: linear programming and game theory. The mathematics department of American University was offering courses in conjunction with the National Bureau of Standards that covered computers and new areas of mathematics. Princeton professors Albert Tucker and Harold Kuhn were doing some work for George Washington University's Logistic Research Project. One or the other came to Washington on Thursdays and would teach that night at American University. In 1953–54, I took their two-semester game theory course. You couldn't do better than that. I also took some math and computer courses, and a course in operations research taught by Joe McCloskey from the Operations Research Office. Joe was a historian by training.

BOB SHELDON: Did the Air Force pay for you to take those courses?

SAUL GASS: No, I paid for them myself, but they were inexpensive. I also became involved in teaching linear programming. George Dantzig taught the first course in linear programming in 1950 at the Department of Agriculture Graduate School. This school is noted for encouraging new material to be taught. George left the Pentagon in June 1952 to work for the RAND Corporation in Santa Monica. The linear programming course was scheduled that fall at the USDA and another professor, George O'Brien, who was a part-time researcher with Project SCOOP and a mathematics professor at a Seventh Day Adventist School in Takoma Park, Maryland, picked up the course. The next year, O'Brien left to become an OR consultant in Detroit and asked me to teach the course. By this time I knew something about linear programming, so I agreed.

I prepared some notes and taught the course for a number of years. I also taught the course to my Pentagon co-workers. One of my friends suggested that I write a linear programming text. This is about 1954–55. Well, who was I to write such a text, but it was an interesting idea. I hand wrote a couple of chapters and sent them off to a number of publishers. A string of rejections followed, until McGraw-Hill

decided to take a look and we signed a contract. I then hired Thelma Chesney from the Operations Research Office to type the manuscript. Gene knew her—she worked in the ORO library and was a great pre-computer math typist. McGraw-Hill sent it out for reviews and all reviewers were reasonable except for one who wrote: "I don't know how many people are now fascinated by 'min cX subject to $X \geq 0$, $AX = b$.' If there are enough of them, this seems a decent place for them to learn how to do it." Foresight!

BOB SHELDON: You don't know who that was?

SAUL GASS: No, I can't even hazard a guess. Probably some non-OR oriented mathematician. That's how the book came to be. About the same time, I got involved with ORO in the compilation of an *Annotated Bibliography of Linear Programming and Associated Techniques*. The ORO editor was Vera Riley who was a staff bibliographer at ORO.

My Pentagon days got me into writing, as well as a new career. I was tasked by Walter Jacobs to write a non-technical pamphlet about linear programming for the Air Force using Air Force applications. It went over well and earned me a nice letter from the general in charge. You can find a couple of the Air Force examples in my text.

Project SCOOP had a very important and positive impact on operations research. Linear programming helped to bring OR ideas away from its military origins. For example, the Air Force, through Project SCOOP, had a research relationship with Abraham Charnes and William Cooper at Carnegie Tech. They were the ones who started the LP killer applications in the petroleum refinery companies. Project SCOOP also pushed the computer field as it supported the development of the NBS SEAC and installed the second UNIVAC computer. We were able to solve linear programming problems of the order of 250×500. That was big in those days, but we knew we needed to do better.

Summing up, Project SCOOP, by introducing linear programming to the world, had a remarkable influence on how we run the world's industries, businesses, and governments. It helped to put operations research on the map. That story is still untold.

But in 1955, Project SCOOP was starting to wind down. Dantzig had left. The Eisenhower administration started to cut funds for such research and the McCarthy investigations were coming close to home. A couple of our mathematicians thought it best to leave government. I was there from January 1952 to May 1955, and left as a GS12.

How did I get out of the Pentagon? I noticed an IBM job advertisement in the *Washington Post* for sales engineers (whatever that was) with a minimum requirement of a degree in engineering or mathematics, and some desirable experience in the use of "automated computing equipment or systems design or methods." IBM also ran the same advertisement in the *Mathematical Monthly*, but there it said they were looking for Applied Science Representatives (whatever that was). So I applied and I was hired by the local IBM office, the commercial (as distinct from the government) sales office, to help the salesmen install the newfangled digital computers at a starting salary of $7,800.

GENE VISCO: One footnote to this, in 1957 I took Saul Gass's course in Linear Programming at the Department of Agriculture Graduate School and that's how I met Saul.

SAUL GASS: He got an A.

GENE VISCO: I have the original text which he published about that time. The more recent editions are about two inches thick; from there on we were friends. I sucked up to the teacher. You said you maintained contact with George Dantzig. Did you maintain contact with any of the other folks that you worked with?

SAUL GASS: I'll come back to George in a while. I have lost contact with most of the others. Alex Orden went to work for Burroughs and then to the University of Chicago. Walter Jacobs, who died in 1982, moved to the National Security Agency where he became Deputy Chief in the Office of Research and Development and then Commandant of the National Cryptological School. Alan Hoffman went to work at IBM Research and is now retired. The other people have dispersed and I have lost contact. There were a lot of people in Project SCOOP that were my age who were not work-

ing in the math area, as I was, but working in the computer area. They were developing what we now call software that ran the UNIVAC and allowed us to analyze Air Force problems. They wrote the first simplex code for a commercial high-speed computer. In terms of personal contacts, Tom Saaty is the only one I have a relationship with. On occasion, I do hear from some Project SCOOP people. An ex-Air Force officer, Lyle Johnson, contacted me recently. His daughter saw an article I wrote on Project SCOOP in *Operations Research* (vol. 50, 1, 2002).

GENE VISCO: At this time when you were in the Pentagon, did the phrase "Operations Research" ever pop up? Did you hear about it? You said George left and went to RAND, so you knew something about what was going on.

SAUL GASS: I don't remember the first time I heard the phrase "Operations Research," but I did find out about a professional society called the Operations Research Society of America. I joined the second year of its organization. I can't say when I attended the first meeting. I have all the volumes of *Operations Research*. I was missing Volume 1, but Bruce Golden bought me a bound version of Volume 1 as a gift. I have ready access to all the issues in my basement. My first paper was published in *Operations Research* in 1954 (vol. 2, no. 3), jointly with Tom Saaty, on parametric programming, followed by a second paper in 1955 (vol. 3, no. 4) dealing with extensions. A third paper, that discussed the algorithmic details of parametric programming, appeared in the *Naval Research Logistics Quarterly* in 1955 (vol. 2 nos. 1 & 2). Both journals started in 1954.

Early on in my Pentagon days, I knew about operations research. I recognized that OR was a rather new profession that combined my background in mathematics and interest in investigating difficult problems that have never been solved before; applied mathematics used to solve a wide range of problems in business and industry. What helped to set it in perspective was the course in OR taught by Joe McCloskey at American University in 1954.

My OR and LP work has concentrated on Federal government problems, which isn't surprising, as I have lived in the Washington, DC area most of my professional life.

BOB SHELDON: The course you took from Kuhn and Tucker, did you take that just out of personal interest in the topic?

SAUL GASS: I guess in the back of my mind was a Ph.D. degree from American University, although I didn't fill a formal application at that time. Later on, I did register for a Ph.D. at AU. In terms of taking game theory and other new subjects at AU, it seemed an interesting thing to do.

BOB SHELDON: Was the course taught because of demand in town for that topic?

SAUL GASS: I think it was a question of "Here's a new field." This program, run jointly by the National Bureau of Standards and the Mathematics Department at AU, was to introduce new concepts in mathematics. I remember going to a conference on game theory at AU, probably in 1954, in which John von Neumann spoke. I don't remember anything he said, but these were the kind of things being held in the Washington area at the time.

In the Pentagon, Project SCOOP ran two very important symposia on linear programming. I missed the first one held in 1951, but was there for the second in 1955 at which I gave a paper on finding a first solution to a linear programming problem. Both symposia presented much new and basic material in linear programming. In the 1951 symposium, Charnes and Cooper gave their first paper on linear programming applied to oil refinery operations.

BOB SHELDON: So you left the Pentagon partially because of the McCarthy era, kicking people out?

SAUL GASS: The whole operation was starting to be downgraded as the administration had cut back on research funds. I just felt nervous on the job. I had a career there but I just felt that the organization that I was in wasn't going to last.

BOB SHELDON: Were they making progress on tackling some real Air Force problems?

SAUL GASS: Oh yes, especially Air Force deployment and war planning problems. That's how it all got started: "How do you manage a war plan?" There were two types of models. One was a Triangular Model (proposed by Marshall Wood) for computing resource re-

quirements which had no optimization. Its structure was a square matrix that could be arranged in triangular form so that Air Force activities at a lower level depended only on the activities at a higher level. This model was used as the main Air Force tool for analyzing planning problems. The linear programming Rectangular Model was too big to be solved at that time. Dantzig and Wood recognized that the Rectangular Model, that allowed for optimization, was the way to go. It had an objective function.

BOB SHELDON: Why the name Rectangular Model?

SAUL GASS: If you have a square set of equations, you get one solution. If you have a rectangular set of equations with more variables than equations, you have some freedom in selecting various subsets of the variables to be in the solution subject to the optimization criterion. You can then move off to better solutions and home in on the optimal solution. Of course, you needed Dantzig's simplex method and a high-speed computer to do that.

In addition to projects on developing planning factors, analyzing spare parts and related supply problems, Project SCOOP used linear programming to analyze the Berlin airlift. The problem was concerned with determining the optimal number of transport aircraft (C47s and C54s) and crews needed to satisfy the Berlin Airlift (1948–49) schedule at minimum cost. The model was not used for daily planning, but served as an analysis and tutorial tool on what linear programming could do.

BOB SHELDON: Can you tell us more about the second UNIVAC computer installed at Project SCOOP?

SAUL GASS: The UNIVAC had a "high-speed" memory of 1024 words with the words stored in mercury delay lines, fairly large tubes of mercury housed in their own air conditioned room. Each tube had some type of crystal at their ends that would bounce the data back and forth. Access time was fast for those days but certainly slow from today's perspective. The main way to store information was on external tapes, a rather slow way to find and access data. We had a lot of tapes whirling around during a run. The staff programmed the simplex method for the UNIVAC and it could solve problems of the order of 250×500. I should note that the first time that the simplex method was programmed for any computer was the SEAC at the National Bureau of Standards.

We had faith and knowledge that the simplex method would work. What is usually cited as the "go-ahead" application was the solution of Stigler's diet problem. It was a 9 nutrient and 77 food problem. You wanted to select a subset of the foods that met the dietary restrictions at minimum cost. The problem was solved by hand in 1947; it took 120 person-days using hand-operated desk calculators. In discussing that problem, George Dantzig would always comment that he wished he had the computational sheets that those people worked on.

BOB SHELDON: That was to minimize cost?

SAUL GASS: Yes, find a diet with minimum cost that satisfied the dietary restrictions imposed by the problem's formulator, the economist George Stigler, who got the Nobel Prize in economics, but not for this work. Stigler's mathematical statement of the problem predated linear programming.

GENE VISCO: I remember some of the results are most unpalatable, do you want a rutabaga?

SAUL GASS: But it does include spinach.

GENE VISCO: You don't remember which UNIVAC that was?

SAUL GASS: It was the UNIVAC I, the second issue, as the first one went to the Bureau of the Census.

GENE VISCO: The ORO UNIVAC, which was by that time called a Sperry Rand 1103, was located right up the street from where we are now at Pearl Street.

SAUL GASS: I remember, as part of my IBM sales activity, visiting George Gamow, the famous physicist, at that location. He was a consultant for ORO and was studying the WW II battle lines, the FEBA (forward edge of the battle area), hoping, I guess, to develop some theory of battle.

GENE VISCO: It was kind of wild as the building that housed the ORO UNIVAC appeared to be a large Quonset hut, which before the war had been a plumbing supply house. And there's a railroad track that runs right nearby. So, here's this computer sitting right

beside the railroad track, and every time a train went by all the tubes would screw up.

BOB SHELDON: The Air Force computer was in the basement of the Pentagon, and your office was on the 5th floor?

SAUL GASS: But we soon moved to the basement. Some of the big wheels stayed upstairs, but my group moved to be with the people who helped us make computer runs.

BOB SHELDON: Did you have to work with the care and feeding of the computer?

SAUL GASS: No, I never did that. I was more concerned with running problems and analyzing the answers. A lesson that I learned from Julian Holley was when he gave me a linear programming problem to solve on the UNIVAC and it turned out that there were no feasible solutions. I brought it back to him and told him that the problem doesn't work out, there were no feasible solutions. He replied that that was the correct answer. He was testing the software. So I learned to make such checks and never trust the programmers.

GENE VISCO: How long did a run take, let's say the 9 by 77?

SAUL GASS: I couldn't tell you exactly, probably a couple hours. Computers were not very fast and we made many overnight runs.

BOB SHELDON: Before we go on to your Ph.D., you were going to tell us why you're not teaching high school.

SAUL GASS: In the last year of your undergraduate program in education you had to go spend a semester as a practice teacher. I got assigned to Brookline High School. I worked under a math teacher who taught sophomore mathematics; he taught the same five courses of geometry every day, plus one course for the not so mathematically inclined. To me, that kind of daily routine was rather boring and didn't seem to be the thing for me. When I got out of school, I couldn't find a teaching job anyway. I did do one day of substitute teaching for the Boston school system at East Boston High. When I came there, the principal told me not to try and teach them anything, just keep them quiet.

GENE VISCO: East Boston was the tough part of Boston.

SAUL GASS: I was paid $10.00 for the day. That's when I started to apply for some jobs. One of my teachers, Andy Zobczyk, tried to get me a job at the Waltham Arsenal, but they weren't hiring at the time. So I registered with the Civil Service as they were advertising for mathematicians. Of course, if you didn't have a Ph.D., you certainly couldn't teach at a university.

GENE VISCO: You said you got your masters in August 1949, and eight months later the Korean War broke out and all the jobs opened up.

SAUL GASS: That's exactly right.

BOB SHELDON: Let's go back to leaving the Pentagon.

SAUL GASS: I worked in the IBM local non-government (commercial) sales office. There was also a government sales office that shared the building. At that time, the office was at 1111 Connecticut Avenue, right next door to the Mayflower Hotel. The building was torn down and replaced by an entrance for the Farragut North Metro station. I went through the regular IBM sales training program, along with the salesmen that joined about the same time. It was a three-week course held in Endicott, New York. I sang IBM songs; I bought a couple of hats. It was just a different and interesting work environment. I have fond memories of my IBM experience. I learned about the business world, and I worked with some great people. They were really bright and talented.

On my first work day, I had to attend a meeting at the Dupont Hotel at Dupont Circle. Here I was, a recent denizen of the Pentagon basement, on a bright day in May, walking up Connecticut Avenue, making sure I didn't get hit by a car as I crossed the streets. I knew that things were going to be different.

My job was to assist the salesmen in selling and installing computers, a far cry from analyzing results from a linear programming computer run. Computers were just coming out, the early IBM 701, 702, 703, 704 machines. The salesmen would strive to replace punch-card accounting machines with computers that were, in general, more cost efficient, even though the monthly rental costs were a bit more. The early IBM computer salesmen made very good commissions.

I continued my training by taking classes at the T. J. Watson Laboratory at Columbia Uni-

versity. I spent three weeks in New York with other applied science trainees learning how to program an IBM 650 computer and taking some general analysis courses. When I returned to Washington my official title was Applied Science Representative. But selling was still part of the job. I would do cold sales calls by visiting an office building, knocking on doors, and introducing myself. It didn't lead to many sales, but I met a few interesting people and the experience was worthwhile. I also learned how to make presentations and to work with non-technical fellow employees. The salesmen were terrific people and we had good times. My office moved to 19th Street into a low one and a half story building that was located right across from where the Palm Restaurant is now located.

The office manager was Ray Fox, who started out as a salesman. I started addressing him as Mr. Fox, but he soon made me aware that that was his father's name and he was Ray. I remember going to Philadelphia for a meeting of applied science representatives and when I came back I found that I had been given a $50 a week raise. They treated you okay and I really enjoyed the work even though it wasn't very technical. I finished my linear programming book during my first year at IBM; it did not come out until 1958. I would go to the Library of Congress (LOC) on Saturdays to do my writing, as it was difficult to write in our apartment with a couple of kids bouncing about. In those days we lived in Arlington and it was a breeze to drive to the LOC; you had no problem parking nearby.

While at IBM, and even afterwards, I kept teaching at the Department of Agriculture Graduate School. In fact, ever since I first started to teach, I managed to give a linear programming course every year at either the USDA Graduate School or American University, and later at George Washington University.

For IBM, one of the companies I helped to install a 650 computer was the CEIR, Corporation for Economic and Industrial Research. CEIR was really the first consulting organization that dealt with the economic aspects of operations research, especially linear programming, combined with the selling of computer services. Later on, they used some of the early IBM electronic computers. Jack Moshman, a statistician from Bell Labs, was one of its early hires, as well as William Orchard-Hayes, the famous programmer who worked with George Dantzig at the RAND Corporation. Bill wrote state-of-the-art linear programming codes for the RAND computers. Moshman was looking to build up CEIR's OR group and asked me to join and head it up. I thought it would be an interesting challenge, so I quit IBM. I bought a second car (an English built compact Hillman) as we were now living in Maryland and CEIR offices were in Arlington in a reconditioned building near what is now Pentagon City. My task was to work with customers, help them formulate problems, and sell operations research consulting.

BOB SHELDON: What year was this?

SAUL GASS: This was in 1959. So then what happened? Well, the US space program started to expand due to President Kennedy's challenge to put a man on the moon by the end of the decade. A friend at IBM, Jim Turnock, who was a Ph.D. mathematician and an ex-Applied Science Representative who I trained with at Columbia University (we shared a suite with two others at the Warwick Hotel), was put in charge of IBM's effort on Project Mercury. IBM was a subcontractor to Western Electric, the company that had won the major contract for the world-wide range and tracking network. IBM's major task was to calculate the space capsule's orbit based on radar telemetry data gathered from the world-wide tracking stations and sent back to the computer control center (to be located at the Goddard Space Center in Greenbelt, Maryland).

Jim asked me come back to IBM and work on Project Mercury. IBM had an implicit policy of not rehiring someone that had quit; they usually don't hire you back. As the work seemed very interesting and challenging, I said yes, and Jim managed to get me rehired. I am one of the few people who got hired back into IBM; another is Herb Grosch who made a name for himself in the early days of computing.

I was put in charge of the simulation effort required to check out the orbit calculations and the related computer programs. That was in 1960. Our offices were at 601 Pennsylvania Av-

enue which also housed the IBM space center computing facility. In October, we moved to Goddard; we were one of the first groups there.

GENE VISCO: Was it IBM Federal Systems Division?

SAUL GASS: No it wasn't, just a separate group within IBM. The Federal Systems Division was not organized until a few years later. We installed twin 7090 transistorized computers at Goddard in a building that was still under construction. Physically, it was a difficult scene. No roof over the restrooms and mud all over the place. I was living in Maryland and my commute was not too difficult, although University Boulevard was then a two lane road.

At Goddard, I was responsible for "dry running" the orbital computer programs with simulated data. We simulated radar data from the world-wide tracking stations and ran the programs in real-time by entering the timed data into teletype machines connected to the computers, as that is how the data would arrive after a launch. By this time, IBM was also given the responsibility of analyzing the lift-off radar data to predict whether the space capsule would go into a successful orbit. This required the installation of a 709 vacuum tube computer in Bermuda. We simulated that phase, plus predicting when to fire the retro-rockets to bring the capsule back to earth and the splash point. Our computer-based system was the first real-time decision-making system with a man-in-the-loop. That is what I was doing until Jim Turnock ran into some difficulties with NASA and they had IBM relieve him. The next thing I knew I was made manager of IBM's Project Mercury effort. That was on May 1, 1961.

It was just before Alan Shepard's sub-orbital flight on May 5, the first US manned-capsule flight. Prior to that we had launches with the chimps Ham and Enos, and a number of test rocket flights. So, it was a tense time during Shepard's launch. I and my co-worker, Al Pietrasanta, manned the twin Goddard computers; all went well. After Shepard's flight, I would go down to Cape Canaveral to watch the launches. I had a group of engineers there responsible for the data transmission from the Cape to Goddard and the running of the control center charts and the launch and orbital plot boards. A very challenging time. I wasn't doing hard OR, but I learned much from Project Mercury that carried over to my future activities, especially the need for testing, validation, verification, and documentation, and, of course, managing people.

GENE VISCO: But you were beginning to become active in the profession; you were a member of ORSA?

SAUL GASS: I was a member of ORSA and I would attend some meetings.

GENE VISCO: You were also a member of WORC.

SAUL GASS: I was a founding member of WORC, the Washington Operations Research Council. Here is a short history of WORC. Tom Saaty spent a post-doc year in Paris at the Sorbonne. When he came back to Washington he mentioned how some of the French OR people would get together informally and discuss things OR, and he suggested that we do the same thing. I thought it was an interesting idea and we settled on the name WORC. We decided not to be affiliated with ORSA so as to cut out the bureaucracy. I am not sure of the year, but it was in the early 1960s. We started as an informal local group and held some very interesting meetings. Washington has always been a hot-bed of OR, and WORC was, for many years, one of the largest OR professional groups right after ORSA and TIMS. I also became active in ORSA by organizing sessions and presenting papers. I believe I organized the first OR and computing session for an ORSA meeting; I had Bill Orchard-Hayes as a speaker. Even though I was in the space program, I still felt that my main career was in OR. My résumé shows few published papers until I joined the university. That was typical for someone who worked in industry; there was little incentive to get things published—you don't get paid for writing papers.

Also in the early 1960s, I was active in the Association for Computing Machinery (ACM) and was one of the founders of the Washington, DC chapter. I served on the ACM Council, and later was Secretary of the American Federation of Information Processing Societies.

BOB SHELDON: Were you still taking more classes?

SAUL GASS: Yes, I was still taking classes at American University. Although I was not

pursuing a Ph.D. with much diligence, I did enroll in the doctorate program in AU's math department. After Project Mercury, NASA's space program moved to Houston and IBM won the contract to install its real-time computing center. IBM's space program was being shifted to Houston. I wasn't anxious to move to Texas.

IBM had a university fellowship program that allowed you to go back to school for a couple of years, given you were qualified and chosen. I applied and got approval for a two-year leave to go after my Ph.D. My boss suggested that I continue at AU. Since I had a choice of going to any school that would accept me, I figured I should look around. George Dantzig had left RAND in 1960 to head up the OR group at Berkeley. I had maintained contact with George over the years, so I felt I should give Berkeley a try.

I visited the Berkeley campus, talked with George and some other professors, as well as the administrative people who ran the Industrial Engineering and OR department; things looked doable. My two children were the right ages to change schools, so Trudy and I packed up and we drove to Berkeley in August 1963. We spent 17 days visiting scenic and other attractions, including the Grand Canyon. The IBM program was great—it paid full salary and transportation back and forth, and they even managed the selling of my Maryland house. My major concern was being able to take the courses, pass the exams, and write a dissertation in two years.

BOB SHELDON: Did you have to sign a commitment paper saying you would come back to IBM?

SAUL GASS: No, I didn't have to sign any such agreement, although there was an implied handshake that you would stay with IBM.

I had to take courses in inventory and queueing, which I did not know much about. You had to pass qualifying exams in these areas, plus, of course, linear programming.

I wanted to take George Dantzig's linear programming course, if for no other reason to become familiar with the notation he was using and to learn from the master. But, because of my background in linear programming, they wouldn't let me register for the course for credit, but I sat in on the course. A couple of friends who took the course with me still tell me about how uneasy they felt when they learned that I had written the first linear programming text. George was using notes from his forthcoming text (*Linear Programming and Extensions*) which came out in October 1963. He then started to use the text. I took all the necessary courses, including a minor in statistics and economics. Of course, I needed a dissertation topic. I thought I would do something in integer programming, but George said that it was too tough an area. He introduced me to Roy Harvey, an analyst who worked for Esso in San Francisco. Roy had an interesting large-scale problem, and I was able to see how it could be decoupled. I came up with a nice algorithm (the dualplex algorithm) that solved it efficiently, along with its theoretical justification, and that gave me my dissertation.

I did okay in the written exams. For the oral defense you were open to questions on everything, especially your dissertation. But first you had to discuss a paper that was outside of your field. I was given a paper by Takacs on queueing theory dealing with busy periods. I had been teaching for a long time, so I was able to come up with a reasonably good presentation. In my talk I used the mathematical term "convolution." When I was finished and opened it up for questions, George Dantzig asked, "What's a convolution?" I was ready for that one. There were no other questions. I lucked out! I packed the family and the Ph.D. and came back to IBM in Maryland in the summer of 1965.

By that time, IBM had formed the Federal Systems Division and located its new offices in Gaithersburg. I became involved with some IBM Federal contracts and managed a group of analysts. All was going okay and I stayed at it for four years. In 1969 I was approached by an IBM friend who wanted to start a new consulting company. I decided to take the chance. We managed to find some backing and organized around five key people. My friend, Belur Radhakrishnan, in whose offices we are doing this interview, was one of them. Rad is a great statistician.

So I quit IBM and helped form World Systems Laboratories. We did pretty well until

mid-1970 when the economy turned sour and our financial backing started to disappear. I left and joined Mathematica, an economics and OR consulting firm with headquarters in Princeton. Oscar Morgenstern was on the board, as well as Howard Kuhn, with Tibor Fabian the president. Tibor did some early OR work in the steel industry and was active in the Institute of Management Sciences. I headed up the local office in Bethesda, a few blocks from where we are now. I did work on mainly government projects for the U.S. Navy, Department of Education, and others. I would read the Commerce Business Daily for targets of opportunity, and write and market proposals. For the CIA, we organized a novel unclassified symposium on techniques for analyzing intelligence information. We also had a contract with the Washington, DC police department to do a simulation of its patrol operations. It did not work out as the people who were interested in it left. A typical story; it's called the "vanishing advocate," which is Dick Larson's term for when a project loses its support as the interested parties move on.

In the spring of 1975, I was full-time at Mathematica and was also teaching two courses in linear programming. Why two? I was scheduled to teach a course at George Washington University. Just before the school term began, I received a call from the chair of American University's mathematics department. He was in dire need of someone to teach their linear programming course. Both were night courses, one on Monday and the other on Wednesday.

In 1973 and 1974, I taught evening courses in operations research for the University of Maryland business department. A friend, Charlie Edelson, an accounting professor, had arranged it. That's how I started to teach at Maryland. In the Spring of 1975, Charlie suggested that I talk to the Dean of the newly created School of Business. The Dean wanted to have an OR department (rather a management science and statistics department) and he was looking for someone to chair it.

I met with Dean Rudy Lamone who, surprisingly, had a Ph.D. in OR. We discussed the job, and I recognized that I would have to take about a 20% salary cut. But here I was working a full-time job and teaching two courses at night. The teaching load at Maryland was two courses for the semester, plus some administrative work and research activities, so how could I go wrong? The interesting thing is I couldn't have gotten that job without my Ph.D. So, when I look back on my work experiences, moving to new jobs every four or five years, quitting IBM (twice), I probably would have ended up teaching at the University of Maryland even if I had stayed on with IBM. Things do have a way of converging. This was a real career change for me. I joined Maryland in September 1975 and I retired almost four years ago. I was there for a long time; I had found a home.

GENE VISCO: What prompted you to write the *Illustrated Guide to Linear Programming*?

SAUL GASS: I always thought that linear programming was such a great subject to spread to the non-technical world; to let people know that mathematicians are interested in solving problems that impact their economic well-being. I got the idea when I was at Berkeley; I was aware that such books were published in other areas.

GENE VISCO: Yes, there was one that came out of RAND on game theory.

SAUL GASS: That's right, John Williams, the head of RAND's Mathematics Division, wrote *The Compleat Strategyst*, a beautiful non-technical introduction to game theory. I wrote the *Guide* while I was working for Mathematica. I found a freelance artist, Bill McWilliam, who worked near my office in Bethesda. He was terrific. I just had to give him the general idea of what I wanted—for example, illustrating the caterer problem with the Mad Hatter's tea party.

GENE VISCO: How about your problems with international publishing? Didn't you have some problems with the Russians?

SAUL GASS: The Russians didn't respect the copyright laws at the time the 1958 first edition of my *Linear Programming* was published. It was translated and published in Russia in 1961; 25,150 copies were printed and sold for 87 kopecks (cheap!). I didn't see a copy of it until much later, but I knew it had been published. I eventually got a copy of the Russian edition from a Bulgarian mathematician I met

at an international meeting. He had studied from the book and still had his copy. We arranged an exchange; I sent him a copy of my latest revised English edition and he sent me his Russian copy.

I had occasion to go to Russia in 1977 under a US/USSR Academy of Sciences Exchange Program. Trudy and I went there for a 30-day visit to Moscow, Kiev, Tbilisi and Novosibirsk. Soon after we arrived in Moscow, I told my Russian "handler," Nickolai, that I wanted to visit the publisher (Mir) of my books to discuss royalties (by that time the Russians had also translated and published *An Illustrated Guide to Linear Programming* without copyright permission).

Nickolai worked on it and one day he told me that the publisher wanted to talk to me and hinted at a royalty payment. So we drove to the outskirts of Moscow to an old-style building that looked like a factory, but nicer—big doors and high ceilings. We were ushered into the Director's office; he wanted to discuss a problem they had with my publisher McGraw-Hill. Mir wanted to publish one of McGraw-Hill's books, but McGraw-Hill was restricting the print run to 5,000 copies. Mir wanted to publish many more than that for the same royalty payment. Russia had by this time agreed to abide by international copyright laws. I told him I would pass his concerns on to McGraw-Hill. Finally, he brought in one of his assistants, a pleasant elderly lady who looked like one of my Russian born aunts. She spoke very good English and had been in charge of publishing the *Guide*. She was going to pay me off. I asked her, "Why did you publish my book just before Russia agreed to the copyright laws?" And, without hesitation, she replied, "It was more profitable for us." She gave me 200 rubles, but took back about six rubles for taxes (it was 6 rubles to a dollar in those days). The remaining rubles were used to pay for Trudy's airfare to Novosibirsk in Siberia. The 200 rubles were for the *Guide*; they did not recognize the need to pay royalties for *Linear Programming*.

But, what was most pleasing to me is that I met many Russians who said, "You were my teacher." They studied linear programming out of my book. It was the first Russian language book on linear programming. Evgeny Golshtein, one of the translators of *Linear Programming*, and I have become good friends and have participated in other US/USSR exchanges.

GENE VISCO: It was the first in English too, wasn't it?

SAUL GASS: Yes, it was the first linear programming text.

GENE VISCO: But the original book, that's been published in a lot of countries.

SAUL GASS: Yes, *Linear Programming* has been published in six languages and the *Guide* in three languages. I have a few jokes in the *Guide* and the Russian translator had a problem with one of them. I tell the joke about the horse who could do mathematics. The farmer, who owned the horse, would brag about the horse's mathematical talents. This got back to a nearby neighbor, a math professor who was on sabbatical. The professor visited the horse and was impressed. When the farmer posed a problem, the horse stomped his feet or used a piece of chalk held in his teeth to write on a blackboard answers to simple problems such as how much is $2 + 2$ or 2×3 or $4/2$. The horse was very good at basic arithmetic. The professor decided to work with the horse for the rest of his sabbatical. Things went so well that the professor brought the horse to his university and enrolled him as a special student in some math classes. During the first semester, the horse managed trigonometry without any trouble. In the second semester the horse did well until the subject turned to analytic geometry. The horse was bombing out. Not wanting to lose its high publicity student, the math department called a special meeting of the faculty to see what could be done. They also brought in a vet and a jockey. Nobody could figure out what went wrong. In a final review of the horse's program, a bright graduate assistant solved the dilemma. "We should have guessed it," he said. "In trying to teach the horse analytic geometry, we were putting Descartes before the horse." So how was that translated into Russian? It really wasn't, but a footnote tried to explain it.

GENE VISCO: That's really funny, the cart before the horse.

BOB SHELDON: Since you've been teaching at the University of Maryland all those years, did you pick up any research topics that were military oriented?

SAUL GASS: I was able to do some consulting during the summer and for the one day a week officially sanctioned by the University. A friend, Dick Morey, had a company doing research for the National Security Agency and he asked me to help out. The company had George Dantzig on the Board of Directors and some other Stanford professors. Morey was at Berkeley the same time I was. I also did some consulting for a local company, Sigma Systems, that had a contract to develop manpower planning models for the Army. This work got me started in manpower planning research and one of my Ph.D. students picked up the topic for his dissertation.

BOB SHELDON: Were any of your students military officers?

SAUL GASS: There were a few in the program over time. The last one I had was Mary Crissey, who was an Air Force Captain enrolled in our masters program. She became very interested in linear programming and OR, in general. She has since left the service (as a Major) and works for the statistical consulting and software group SAS. We also had a helicopter pilot who was part of the White House Marine crew. For his master's thesis, he worked with one of our OR professors, Larry Bodin, to develop a helicopter scheduling model for the White House helicopters.

BOB SHELDON: At INFORMS you were also involved with MAS?

SAUL GASS: I've always been a member of the Military Applications Section, now the Military Application Society. I've never been an officer, but I served for many years as the chair of the MAS sponsored Jacinto Steinhardt prize award committee for outstanding contributions to military OR.

I was involved with the MORS working group on model validation, verification, and accreditation—VV&A. I had experience in that area through consulting work for the National Institute of Standards and Technology (NIST). This goes back to the mid-1970s and 1980s when NIST had some contracts with the Department of Energy's Energy Information Administration (EIA). EIA was (and is) quite concerned with the validation of its models such as the Project Independence Evaluation System (PIES). EIA used PIES to evaluate proposed energy policies, the results of which were used by the Executive Branch in proposed legislation sent to Congress. Congress wanted to know how the numbers were derived—what made the models tick—so there was a need to develop formal and explicit verification and validation procedures. This need also led to the important concept of third-party independent evaluations of critical models. I have written "how to" papers about these important aspects of a modeling project.

The Government Accountability Office (GAO) became involved in VV&A and I did some work with them, especially with Bruce Thompson and Christine Fossett (who is active in MAS and MORS). Bruce and I were instrumental in GAO's breakthrough publication "Guidelines for Model Evaluation," and Chris, Harry Weintraub and I helped to write a GAO assessment procedure for simulation models. Based on this work, I was asked to participate in the MORS VV&A working group.

GENE VISCO: About this time you also co-edited or co-published a book of models that dealt with civilian applications.

SAUL GASS: Yes, that is when I was with Mathematica. We had a contract from EPA to do a survey of modeling in the non-military governmental area. I co-edited it with Roger Sisson who did some early and important research on simulation. There was much interesting work being done and Peter House, who was at EPA, thought it should be compiled. We were able to get well-written papers by the relevant experts.

GENE VISCO: And you published that yourself?

SAUL GASS: Yes. What happened was that Mathematica's contract called for the delivery of 1500 hard-covered copies to EPA. I don't know what happened to them. They just disappeared. Roger and I thought that the book had much value, so we went into the publishing business. We named ourselves SAUGER—Saul and Roger. Trudy was the bookkeeper; our shipping room was my basement. I was able to get the photo negatives of the book from EPA and have a local Maryland company print 1000 hard-bound and 1000 unbound copies. We advertised the book in *OR/MS Today*. It was used for a course at Georgia Tech and some other

schools. We sold all of our copies. It was an interesting activity—we learned that not everyone wants to pay their bill!

GENE VISCO: Another contribution was the *Encyclopedia*.

SAUL GASS: Right, *The Encyclopedia of Operations Research and Management Science*. I had not thought about doing an encyclopedia but was approached with the idea by an editor from Kluwer Academic Publishers (recently acquired by Springer Scientific). Kluwer already had published a few such encyclopedias. It certainly was an interesting and challenging idea. I recognized that I would need some help, especially in the areas of probability, statistics, queueing, that is, the stochastic side of the field. My dear friend Carl Harris agreed to be co-editor. It took a couple of years to do and came out in 1996.

GENE VISCO: Carl was at George Washington University.

SAUL GASS: He started at George Washington, spent a couple of years at Syracuse and the University of Virginia, and, when we wrote the *Encyclopedia*, he was chairman of George Mason's Department of Systems Engineering and Operations Research. That edition sold about 1600 copies and was translated into Japanese. I believe that most of the copies went to libraries.

GENE VISCO: It is very expensive.

SAUL GASS: The current list price is about $500. A few years after the first edition came out, our editor, Gary Folven, suggested that we do a second edition, which we did. We added some new topics and had the first edition authors update their articles. Carl and I finished the manuscript in February 2000, and then, suddenly and tragically, Carl died in April. The second edition came out in October and is being translated into Chinese.

GENE VISCO: He died young, didn't he?

SAUL GASS: Yes, he had just turned 60.

BOB SHELDON: I'm going to backtrack 50 years again. You said you picked up linear programming by reading George Dantzig's papers. Did it seem like a natural subject to you, easy to comprehend, or was it a struggle for you to learn from reading the papers?

SAUL GASS: Initially it was a bit of a struggle. The math I could understand, linear equations and related ideas. The papers were well written, but this type of optimization was really new, as well as the concepts behind duality. It took me a while to understand the economic implications of duality. I'm still learning.

One of George's papers was on the equivalence of the linear programming model and zero-sum two-person games. To me, this relationship was fascinating. Here we have two outstanding mathematical developments of the mid-20th century—linear programming by Dantzig and game theory by von Neumann—related in a remarkable way.

It really blows my mind how these two different concepts mesh. You should read Dantzig's article in which he describes a trip to Princeton for meetings with Al Tucker and John von Neumann. Von Neumann, who was unfamiliar with linear programming until Dantzig described it, suggested to Dantzig that the concepts were related and this led to the duality aspects of linear programming. We should note that much of the formalism of duality was developed by Tucker, David Gale and Harold Kuhn.

GENE VISCO: Saul, what kind of advice would you give to young people interested in Operations Research?

SAUL GASS: I think for someone who has a mathematical background, especially an interest in mathematical applications, OR is a beautiful field to work in. Many mathematically talented people do not want to teach or have the interest in doing theoretical research or end up as computer analysts or work on engineering-based problems. OR gives them the opportunity to apply their knowledge to a wide range of real-world problems that occur in all aspects of business and industry, government and military, and in societal problem areas. They can use their mathematics to attack a wide range of problems. And there are still many interesting problems yet to be solved. To make a mark in the field, you really have to get at problems where nobody else has investigated or has been successful at resolving them. New problem areas are difficult to find and are often difficult to solve. But, analyzing them in terms of the systemic and algorithmic aspects of OR can often lead to breakthroughs.

I've seen that happen in the police area based on the work of the Science and Technology Task Force of President Johnson's Crime Commission (1966). The Task Force, directed by Al Blumstein, who was then with the Institute of Defense Analyses (IDA), employed a number of OR people. I joined the Task Force on assignment from IBM, along with OR analysts from IDA, as well as a few graduate students, in particular Dick Larson from MIT. Some great work came out of applying OR ideas to this new area, especially Larson's hypercube queueing model for deployment of urban police patrol cars. His work has since been extended and applied to fire and ambulance emergency services. The theme here is "new people looking at new problems." That is how OR got started by the British in the days just before WW II. It has since happened in the airline industry, medicine, and now in the biological sciences. For those who have an OR education and do not want to teach, there are many opportunities working for companies with the problems or in consulting organizations who contract with those companies. Well trained OR people attack problems with a different outlook—OR enables the full range of decision-making ideas and procedures to be brought to bear on important and interesting problems.

I don't mean to imply that you just dip into the OR toolbag and pull out, say, a linear programming hammer, and attempt to apply it to the problem at hand. You need to understand the problem and its environment and look at the full range of applicable ideas. There's always the difficulty of closing the loop and working with the right people who can get things done for you, especially if you're not with that company, you're in as a consultant.

I like the consultant field. I would tell my students that if you have a good background in OR and have a reasonably good understanding of how to use a computer as a tool for analysis, you won't have difficulties finding a job. There are a lot of opportunities out there. The advantage to going into the consulting field is you get involved in new problems; you usually don't get stuck in very long-term projects. Consulting companies, if you work for a good one, are always finding new work. You do such consulting for a few years and get great exposure. Then you may tire of that and maybe want to run your own company, or get an advanced degree and go into teaching OR. Your consulting experience will make you an informed and better teacher. A difficulty we have in OR education, and this has always bothered me, is that employers of our graduates complain that OR students aren't trained to start to work on real-world problems; they can't do real problem solving. Well that's true for any profession. Lawyers and doctors serve as apprentices for the first couple of years—those professions make it part of the process that leads to becoming an effective lawyer or doctor. For some reason, we just don't have that concept embedded into the training of an operations researcher.

There are a few universities that have OR programs where the students, as part of their training, are assigned to work on real-world company-based problems. That's very good exposure for the students. The companies that first hire our graduates need to recognize that the student's university gained knowledge must be nurtured and made more valuable by having the new employee go through an apprenticeship period, just as we do for other fields. We can't expect our students to come out full blown, it's not the case. Hopefully, you work for someone who's been there for a while and can help guide and train you.

University programs in OR have gone through good times and bad, and right now we're sort of in a middling period, especially for OR/MS programs in business schools. We seem to cycle through good and bad times. You just have to wait for the next cyclic change; interest in OR is going to rise. Gene and I have been in the field for a long time and we have experienced such cycles. There are always opportunities for trained people to work in the OR field.

BOB SHELDON: What are your observations about Operations Research in the 1950's—the early days—versus the last decade?

SAUL GASS: I've been going through some of my files, cleaning things out. I found old Pentagon files that include some flow charts and other problem definition material. Earlier, when I was talking about linear programming in the Pentagon, I probably gave the

impression that everything was well defined; you have a linear programming problem and so on. But if you take a look at some of the early Air Force deployment problems, where people had to make decisions, it really is not a straight optimization problem. The last problem I worked on at the Pentagon was an Air Force deployment problem. I had to block it out, flow chart it, and, when dealing with a decision box, make some assumptions as to how the analyst (now the computer) decides what to do. We didn't call it heuristics at the time, but that's basically what we did. We discussed this with the people who were responsible for solving the problem—we'd ask what do you do here and why? When I look at what we did during the "early days," we were not so formalized as we are today. We also didn't have enough computational power. Simulation helped quite a bit in our ability to attack some of these not so well-defined problems and test out ideas.

Jumping from the past to present, we are still weak in the verification, validation, and accreditation (VV&A) aspect of what we do. This applies to most modeling activities. The military and other governmental agencies, such as the Department of Energy and the Government Accountability Office, have been the main drivers in this area. Models in the military have a long shelf-life; the people who developed them move on, but the models stay behind and are kept in use. The data continually changes. Spreadsheets are now a main analysis tool and are often poorly documented; you have to know the basis of their formulas and where the data came from. VV&A has to be an explicit part of all modeling efforts, backed by staff and money to do it. The same goes for documentation. Documentation is usually the last thing that is done in a modeling project, but you can't do VV&A unless you have an initial documentation plan and carry it out. And you can't evaluate a model unless you have documentation and a record of VV&A activities. From day one of a project, documentation has to be an ongoing activity. I have worked in and have written a few papers about VV&A and documentation. As research items, these topics do not turn many people on, but they should. When involved in a modeling exercise, VV&A and documentation are things I would be concerned about. VV&A has to be a worrisome aspect of OR modeling. VV&A has to be a mainstream research activity.