1. Early Life Through College

MARK DASKIN: Hi, I'm Mark Daskin, I'm a faculty member in the Industrial and Operations Engineering Department at the University of Michigan, and I serve as the chair of that department. And I'm here today with my friend and colleague, Steve Pollock, who was also a faculty member at the University, was also a chair of the IOE Department, and is now an emeritus colleague. Do you want to introduce yourself?

STEVE POLLOCK: Thank you, Mark. You did a good job of introducing me.

MARK DASKIN: OK. Well, tell me a little bit about your background, where were you born? Where were you raised?

STEVE POLLOCK: I was born and raised in Brooklyn, New York. I was nine years old when the Second World War was over, and so I was little and excited about that. I went to a local grade school and a local high school, which actually was a very famous high school. A number of people have gone to it, even though it's just a plain public school.

MARK DASKIN: So who else other than you has gone to that high school?

STEVE POLLOCK: Let's see. Bernie Sanders was there.

MARK DASKIN: OK.

STEVE POLLOCK: Ruth Bader Ginsburg went there. A bunch of other people. Anyways, but it was a very neighborhood kind of high school, that was good. My father was a musician, violinist. My mother was a teacher. And it was very nice middle class home.

MARK DASKIN: So what did she teach?

STEVE POLLOCK: She taught music. My parents met at Juilliard and they're both musicians.

MARK DASKIN: So it was sort of a noteworthy marriage?

STEVE POLLOCK: If this interview is going to consist only of puns--

MARK DASKIN: It could be a long interview.

STEVE POLLOCK: It wasn't until I graduated high school that I realized I had to decide what I want to do with my life.

MARK DASKIN: But that does raise a question for me. If both your parents were musicians or in the arts, when and how did you develop your affinity for math and operations research and physics?

STEVE POLLOCK: That's a good question. I really don't know. I sort of liked the mathematics courses that I took. And we had an introduction to physics in high school. And I liked that. But I also liked the history course. One of my teachers thought I should try to go into one of the sciences. I'm not quite sure why. And I said, sure, why not? I'll try it.

So it was nothing particular that-- in fact, for a while, I thought I might be in maybe English or something like that. But I did well in the Regents exams that they had in Brooklyn at the time, and I did very well in the math and sciences. I think it must have been one of my parents or somebody in my family who insisted that I think about that when I went off to college. So.

MARK DASKIN: So you went to college, if I'm not mistaken, at Cornell, right?

STEVE POLLOCK: Right. That was interesting. I was clueless. I had no idea where I should apply. And somebody suggested I should apply to MIT, and I should apply to Cornell, I should apply to Princeton, and I should apply to Columbia. I didn't know anything about these schools. They were just-- my parents and my relatives would come up with these names. Never visited any of the schools.

MARK DASKIN: It was hard to look them up on the internet at the time.

STEVE POLLOCK: Well, the equivalent of the internet was my grandmother, and she wasn't very helpful. So I finally applied to all of them. And I got a Regents scholarship which allowed me to apply the money to any university in the state. The only other available place then was Cornell. So I went there.

MARK DASKIN: And you majored in physics, right?

STEVE POLLOCK: In something called engineering physics, actually. It was a new area, a new discipline. The invention of the-- shoot, I'm stalling now on the kind of electronics that allows you to make--

MARK DASKIN: Transistors?

STEVE POLLOCK: Transistors. And the idea was to put together a department which would be able to develop what we know about transistors and come up with all sorts of new things. And it was called engineering physics.

I was talking with Al Blumstein at lunch today. He was in the engineering physics undergraduate program. It was very small. When we started, I think there was something like 18 people in the program. And I think we graduated out, like, 10. Everybody else went off to plain physics or chemistry or something like that. I didn't know the first thing about what it was going to be.

I had an advisor in the physics department who you went to see every term who to approve the courses that you were taking. It wasn't until I graduated in graduate school for a couple of years, I realized that he was Hans Bethe. I'd never heard of him and I didn't know who he was. But I

was pretty surprised to think that little guy that spoke to me, he was really that famous-- so it shows how naive I was at the time.

MARK DASKIN: So there's actually a story that my parents told about that, because there's a paper by Ralph Alpher, I guess, Alpher and--

STEVE POLLOCK: Right, and Hans Bethe.

MARK DASKIN: And they added Gamow after this, so it would be-- right.

STEVE POLLOCK: Right, the Alpher, Bethe, Gamow

2. Graduate School in Physics

MARK DASKIN: Right. So how did your background in engineering physics impact or influence your decision to go into operations research? You got a masters in physics at MIT.

STEVE POLLOCK: I went to MIT, right. Got a master's in physics. I was in the PhD program.

MARK DASKIN: In physics?

STEVE POLLOCK: In physics. I became a research assistant working on some high-energy physics problems that one of my friends who was a graduate student -- that was his research project. And I enjoyed climbing up and down all over the synchrotrons and cyclotrons, going out to Brookhaven, and stuff like that.

But then I realized I was spending a lot of time climbing in and out of these machines, and we were taking images on a spark chamber, taking about 300,000 images. That was reduced to about 50 usable ones. And the 50 usable ones, you had to make some knowledge out of that, say what sort of interactions were happening, what sort of energy was being engaged. You write a paper, and fine, that was the end of three years. You have written a paper, and now you got to do that again.

And I realized, I don't want to do that. I mean, although I liked climbing around on the equipment and working with the liquid hydrogen and so on, I just didn't view myself as being not really producing anything than just papers which were sort of interest to other physicists.

Philip Morse was the chairman of the physics department when I first came to MIT. And it was before I enrolled. I met with him on Easter vacation to find out what the program would be like.

I noticed something on the wall of his office which said something about operations research. I had only heard about operations research from a summer job that I had the year before, when I was a physicist at AVCO in the summertime. And so I asked him, could I do jointly operations research and physics? He said, well, you're going to register in physics. You're going to really have to be a physicist first.

And that came to me after I didn't pass my first set of exams. And I asked him, can I do something like that? And he said sure. But you know you're still a research assistant on this project. Get that project done, and then we'll see what can be done.

And so in the course of getting the project done, I had to fit curves to the data that we had come up with. And I asked, well, how do you do that? How do you fit the curves? He says, well, use the least squares method. And I had no idea what the least squares method was, because MIT did not have a statistics department at the time. And I didn't think it was necessary to take a statistics class.

So I had to read up on it and then I came back and I asked my supervisor, who was working on this cyclotron, why do we use least squares? Why not use least absolute value, or least mean cubes, or something like that? Where'd it come from? And the answer was that-- and he wasn't actually sure, because he was a physicist. But I spoke to people about it. And that was because if you assume that the error that you have has a normal distribution, then it's really easy, you get a nice analytical solution, doing least squares.

And I thought that was a pretty bad reason for doing something. But I did. And I said to him, you know, maybe I am going to get out of physics, and I'm going to go into this area where I can take advantage of the fact that I didn't understand least squares and maybe I can do something with it.

And so Philip Morse introduced me to Ron Howard, who was at the time the head of the OR unit at MIT, and I put together a very nice problem which dealt with submarine search, looking for what's the optimal search you should do when you have a moving target, and how you should relook for it and so on.

And so my physics sort of shoved me over into not being in physics, and being in something a little bit more operational, something I could touch. But it was something that convinced me I shouldn't be a physicist.

MARK DASKIN: So I can imagine that optimal search for a moving target would be good training as a department chair, when you're trying to figure out what a dean wants.

STEVE POLLOCK: Right, or you're trying to figure out how to avoid somebody who wants to come find you.

MARK DASKIN: Right. Right. That's the flip side. That's the dual of the problem.

STEVE POLLOCK: Right. But then I had to take my second PhD exam, even though I was going to do a dissertation in operations research, because my department was physics, and they weren't going to let me go without passing it. So they gave me one of these word problems to solve: A person was hit by a car. The person flew 60 feet before he landed on the ground. The angle, and the contact, and the physics was such that that was the absolutely maximum distance that this person could have flown. How fast was the car going?

I knew I had to do conservation of energy. I knew I had to do conservation of momentum. I knew how to do something else. You know, there were three equations I was going to have to solve. And there was no way that I could do that standing up in front of people. But then I realized that, look. I was given a problem with only one piece of data, which is 60 feet. And the only other thing that was involved was the force of gravity, OK, force of gravity, G, was 32 feet per second per second squared.

So it's feet per second squared. I'm looking for something which is the optimal velocity, which is distance per second. So how do you make distance per second squared into distance per second? You multiply it times distance and take the square root. So I took the 30 times the 60, took the square root of that, and I came up with that answer. Phil Morse looked at me, and they sort of poked each other, and laughed. And said, well, that's not quite right.

I said, well, I know I should have done conservation of energy-- but I'm sorry. They said, it's OK. You were just off by a square root of 2. And clearly, there should be something like a square root of 2 hanging around.

So the message to me was that I was trying to solve the problem. I was not necessarily doing mathematics. I was not necessarily doing physics. I was trying to solve the problem. And the problem involved things like mathematics. What are you trying to do? What are you trying to get? And that, I think, in retrospect, that really sent me on a path of operations research, because that's what it's all about, finding out what the problem is. What data do you have? What are you trying to do? How do you simplify before you make it complicated? And so I'd say that that was a good start.

MARK DASKIN: I think a lot of the early pioneers of operations research were physicists.

STEVE POLLOCK: They were.

MARK DASKIN: Bob Herman, for example.

STEVE POLLOCK: Bob Herman was a physicist. Phil Morse, certainly. Well, the next person who was my boss was George Kimball, and he was a chemist.

3. First Job at Arthur D. Little

MARK DASKIN: And you went from MIT to Arthur D. Little, is that right?

STEVE POLLOCK: That's correct. What happened is I had a summer job there, one summer, just before I got my degree. I liked it. So I started to work for them after I got my degree.

And my boss then was George Kimball. I worked with other people, Martin Ernst and Bernard Koopman, Jim Gavin. General Gavin was the head of Arthur D. Little at the time, an army paratroop general. He was a very analytical kind of guy. He was easy to work with. So I worked with them for about a year and a half. It was very exciting. And I did a variety of operations research things.

MARK DASKIN: So what sort of things did you work on there?

STEVE POLLOCK: There were people at Arthur D. Little that were working on projects, and I was asked to-- as a junior employee, to help with some of the stuff, do the analysis, do the modeling, and so on.

At Anheuser-Busch, there was an interesting problem. They produced three different kinds of beer, but they had a single production facility with either five or six production lines. And the big issue was, when should they stop production of one kind of beer and go to the other kind of beer? And that's when I noticed, that's where I learned that the difference between beers is essentially how long that you keep them, rather than what's in it.

Then I worked with social workers helping people with blindness. How many social workers should you have? Where should they be allocated? And so on. I did a lot of military stuff, trying to understand where you should put undersea submarine sensors, helping with the design of the SOSUS system, which was locating receivers on the ocean floor, from Iceland all the way down the East Coast, to east of Florida. it was a highly classified system. And the question is, where should they be located? And should you lay them out in a line? Should you randomly put things? And so on. And at the same time, they were using sonar buoys, things were dropped out of airplanes, particularly if you thought a submarine was in a particular location. What should the policies be using that? And that was very exciting.

I was on a project where it was my responsibility to try to figure out how good machine translation was compared to human translation. By "translation," I mean translating, in this particular case, from Russian to English. The Air Force was getting a lot of Russian technical documents, and they wanted to be able to translate them very quickly. And IBM had come out with a new system that was purporting to be able to come up with good translations. However, that meant you used the computer, and then you gave them to a Russian speaker, who looked at the results and cleaned things up, because clearly it was not doing it very well. And the question is, which was more efficient?

One of the projects that I and Mike Maltz, who is a member of INFORMS, did some work on dealing with drone vehicles that were carrying torpedoes, used to drop torpedoes at distances that were too far for a destroyer to use to send rockets over. And the most interesting problem was the fact that you had to have these drone helicopters, flying from destroyers, the little landing platforms in the back, and that was very, very difficult, particularly in rough water. And they didn't succeed very well in operational testing. But they killed the program. Unfortunately, when you run an operational test, you have not only these drone helicopters, but you have airplanes going around, and airplanes in no way want to mix the airspace with the drones, so the drones were constrained to be below something like 3,000 feet, in which case they kept going into the ocean. So instead of doing the tests without the airplanes around, they decided to stop it. So that's what I did at ADL, and that was a lot of fun.

4. Naval Postgraduate School

MARK DASKIN: But then you went to the Naval Postgraduate School.

STEVE POLLOCK: Yeah, I gave a paper at San Francisco, and Jack Borsting, who was putting together the operations analysis group, liked the paper, and he went up to me afterwards, and he wanted to know if I'd be willing to go down to Monterey for a day and take a look at the Naval Postgraduate School, take a look and see what I think of it. It's pretty hard not to like it. It's beautiful.

And he said, how would you like to come here? at the time, I had one child, and I really wanted to spend more time at home. And I realized that Arthur D. Little, I was constantly taking a trip somewhere, constantly going out to the clients. This would be a nice place to be an academic. And I decided to go there. It was really on the spur of the moment.

MARK DASKIN: But you were there only a couple years, and then you went to Michigan, right?

STEVE POLLOCK: Yeah I was there four years. It was a tough four years, because it was during the Vietnamese War. And I'm sort of a pacifist. I really didn't go very much with the politics of the war. And the more I was there, the more upset I was. I was teaching mostly naval officers, some Marines, some Army, some Coast Guard. And I figured, we always have to have an army. We always have to have a defense force. There's no two ways about it. If we're going to have one, we might as well have the best educated soldiers and sailors. So my mission was to do as best as I can to make sure that the students there were well-educated, even though their next job may be to go into Vietnam and do something that I was not particularly happy about. But at least they were thinking about it. They're not doing it blindly.

But after a while-- this was 1969 or so-- I finally decided I was going to leave. I heard a great talk by Al Blumstein about the use of operations research in helping non-military situations. He was talking about using them in social areas,

MARK DASKIN: Was he working on criminal recidivism at the time, or did that come later?

STEVE POLLOCK: He was working on analysis of criminality in general. And the recidivism came up later, actually. And I got an offer at Michigan.

MARK DASKIN: The weather there is so much better, anyway.

STEVE POLLOCK: I used to be asked, the first couple of years I was in Michigan, people would say, oh, where did you come from? I said, I came from Monterey, California. They'd look at me and say, why in the world would you come from Monterey to come to Michigan? And my only answer was, I'm too young to retire. And I was, because in Monterey, it's a beautiful place.

It was a great educational institution. It had excellent departments, and I think their operations research department is still one of the best in the country, if not the best, by some measures. They have good mechanical engineering, good electrical engineering. And they had a political science department. I don't know what they have now, but it's not a great liberal arts university. And so coming to Michigan was, I thought, a good change for me. And frankly, I thought I would be there for about three or four years, and end up on the East Coast. Never happened.

5. Industrial and Operations Engineering at Michigan

MARK DASKIN: So, you were also chair of the IOE department. When were you chair?

STEVE POLLOCK: Yeah, I became chair in the early '80s. When I first got there, the chair was Walt Hancock. But then when I got there, it was Dan Teichroew. And he was the chair for a while. And then Don Chaffin for about three or four years. And I guess somebody must have said, hey, anybody want to be chair? And I raised my hand. And the tradition there was hiring chairs from the department. And so I was chair till '90.

MARK DASKIN: So what were the big issues in the department at that time? Were we still on the main campus, or--

STEVE POLLOCK: No, we were on Central Campus. And a big issue was moving the entire department into North Campus. North Campus at the time was only mechanical engineering, starting up electrical engineering, and then music, the music school, and the art and architecture school. Engineering moved piecemeal up

So it took about 10 years for the entire college to move up to North Campus. And we did it in about a year and a half. We took an old building that had belonged to Central Campus, and we made it into an academic building.

MARK DASKIN: So how many faculty were in the department at that time?

STEVE POLLOCK: At the time, I think we had about 14 or 15 faculty.

MARK DASKIN: So it's about half of what we are now.

STEVE POLLOCK: Yeah, half of what we are now. And we did a lot of hiring at the time. John Birge, Jim Bean, come to mind, at least the OR people. Bob Smith. Some other people came, and then they left, for various reasons. If you have a department and the only thing you do is hire, that's stagnation. And so if you get people coming through, and for some reason, leaving things behind that we like, or which we learn from, that's important.

And I think one of the nicest things I ever did, was to change the name of the department from industrial engineering to industrial and operations engineering. And I did that because I didn't want to lose the operations research.

And this was in '71 or '72. I was still a very junior faculty member. And I just wanted to get operations research in the name of it.

But there was some pushback, because about every 15 years somebody says it's a lousy name, let's come up with something else. But I thought it was pretty good. As I was trying to think of what a good name would be, is that we didn't have a department of mechanical engineering research. We didn't have a department of physics research. We had departments of physics. And so I thought, OK, well, let's say it's the Department of Operations and Industrial Engineering. We

don't need the word "research," because it's a university, we're going to have research. It's automatic.

I think it was really great, because first of all, we had the word "engineering" in it. And we were in an engineering school, and it showed where a base was, that the kind of problems we were dealing with had engineering content, even if it's not necessarily hard engineering. It could be social engineering.. It could be medical engineering. And it allowed us not to be eaten up by the business school.

MARK DASKIN: Right. So it reminds me, when I was Vice President of publications at INFORMS, Ed Kaplan, who's now the president, was on the board. And he and I would sit together. And this was right after the merger.

And there was a discussion at one meeting about whether INFORMS was the right name. So one of us proposed the name the Institute for Decision Information and Operations Technologies. And everybody sort of liked that, until we pointed out that the acronym was IDIOT. And that stopped the discussion pretty quickly. I wanted us to have T-shirts that said "I are an idiot" or something like that.

STEVE POLLOCK: Well, there was a unit of the Navy called the Operations Research Group for Anti-Submarine Measures. That was seriously considered back in 1946 or '47, until it turned out to be ORGASM, and they said they didn't want that one either.

6. Choosing Problems to Work On

MARK DASKIN: You got to watch out for these acronyms. So let me turn a little bit to some of the work you've done in your research. When I look at it, it's a very eclectic collection of papers and topics. And so I guess my first question is sort of, how did you come to some of these problems? How do you select what you want to work on?

STEVE POLLOCK: I plead guilty. OK, eclectic, I can-- maybe there's another word that-- maybe ragtag? Again, what I realized was that what I was really good at, trying to figure out, what is the problem? How would we know if we improved it? What are the tools that we would need? And hopefully those tools would be analytical tools, which is where my background, or where the department's background is. And then let's go ahead and see if we can solve these problems.

And so whether or not the problems came up in transportation or in manufacturing or in the military or in social affairs or in athletics, it makes no difference. And I sort of liked that idea, and it also allowed me to work with lots of different people, because they had the subject area expertise to be able to say what happens, what doesn't happen. And I'm pretty good at asking many stupid questions, one or two of which may actually be good questions, which lead us into a way to look at things.

And if you look at some of these papers, you'll see some of them are really simple-minded, almost, because they have to do with identifying an objective function, which maybe people

hadn't thought of before, and that pertains to the problem, and so let's see what we can do with it. So you're right, it was sort of eclectic.

And when people would ask me, well, what's your specialty? It sounds a little bit self-promoting to say, oh, my specialty is solving problems. But in a way, let me say my specialty is trying to approach the solution of problems, and seeing, maybe can I hand off the details to somebody else?

MARK DASKIN: But, in my mind, that brings me to a course that you developed at Michigan, which is, unfortunately, no longer being taught. But it's IOE 640, which was a course-- the way you described it to me at one point was, you'd walk into the class. It was a PhD class. And you'd talk for 20 or 30 minutes describing a problem. And then you'd say to the students, go deal with it.

STEVE POLLOCK: Right. That's exactly it. A typical course would be maybe four, possibly five, problems over a term. You were given two weeks to do the best you can on them. And sometimes they were complete flops. Sometimes they were really interesting. Sometimes they led to professional and publishable papers.

And so I can bore you with all of the things. But it's sort of fun. Early on, I remember I was walking through the hallways of the old building, before we moved up to North Campus. And Bert Steffy, one of the faculty members, was a great golfer, and he was cursing to himself one day, and I was walking by. I said, "What's wrong?"

He said, "I've got to go play with so-and-so, play golf with him. And this guy wants to play match play, and I want to play medal play."

I don't know anything about golf. I said, "What's the difference?" And he explained to me match play and medal play. One had to do with how many strokes you need to finish, and medal play is how many holes you win. Maybe I got it backwards. It shows you how much I know. But I said, "Well, it's an interesting question."

And he says, "Yeah, because he insists upon playing match play, and he just beats me all the time."

And so I brought it to the students and said, this is an interesting problem, and I helped Professor Steffy figure out whether or not he should play medal play or match play. At the end of two weeks, almost all of the students came up with interesting approaches. All of them were not doable. Then a couple of weeks later I put together an analysis and published it in *Operations Research*. And I think it's probably the most viewed paper I published in *Operations Research*, having to do with should I play medal play or match play.

So, but we had all sorts of other problems. Should we have rotaries or traffic lights? I had a situation where there's a big intersection which has only stop signs. There's no lights at all. And the question is, should they keep the stop signs, or they should put a rotary in? Now, granted, the

civil engineers solve this problem all the time. But these are a bunch of non-civil engineers. They only had two weeks. And they had to figure out, what are the issues?

And one of the interesting things is the performance measure is not necessarily-- you would think it would be the expected waiting time that a randomly arriving car has to get through the intersection. And maybe weighted by the traffic coming in different directions. But one of the students in the class pointed out that it's not necessarily you're really annoyed because you have to wait, on the average, you know, 23 seconds. But you're annoyed if you have to maybe stop two or three times before you go through the intersection. And that gives you a completely different solution than in fact the one that minimizes the waiting time. And so the idea that you have different objectives.

I came in with a military problem that I had been working on as a consultant, and I cleaned out the confidentiality of the issues. But supposing you have a road in which a vehicle, say, a tank, is driving along the road, and you have a piece of artillery. And you would like to be able to fire-- you have one round. You want to fire it on the tank. And the tank has stopped somewhere. And the question is, where should you aim? You have two different sources of information. People have gone out to try to figure out where the tank is. One of them is on this side, this particular place. The other one is this particular place. They may be a couple of hundred feet apart, and you believe both of these people are equally talented, who are reporting where the tank is, and you've got this one round. Where should you put it?

Now, it seems intuitively clear that if you have them very, very separated, then you have no idea which one it is. There's a 50/50 chance of being at one or the other. You just randomly pick one and fire on it. That seems reasonable. But if you have a distribution, say, for each place, and as they start coming closer and closer together, at some point, you want to fire right in the middle, because the lethality of the weapon is such that it can reach to the right and to the left. And there is a magic number such that you fire either one or the other, one or the other, one or the other, in the middle. It's just instantaneous. And it came out of a course problem.

I have one son who is a diving instructor, diving coach, at the local high school. He said, you know, when they put together the rosters for the swimmers, the coach has to put in which swimmers are swimming which events. You can only put in a maximum of three. And which ones should you put in there? There are some swimmers that are good in three different strokes, and you're facing another team which is doing the same kind of thing. How should you set up the line-up on your team?

And I said, I don't know, but I'll bring it into the class. And it was really exciting, because we had a lot of data. And it involved, among other things, the probability distribution over how fast each individual is going to go. You can get that from the other teams by looking at their past records and so on. And we were able to put together a very nice optimization program, non-linear programming problem, would solve the allocation. It was a real problem, and it led to non-trivial kind of things. Actually, it turns out there are many, many thousands of swimming coaches all over the country that really like to see that.

MARK DASKIN: I think, for me, one of the things I liked about your description of the course is that it wasn't a course rooted in any one methodology. And from what you said to me at one point, this gave the students a lot of discomfort, because if it was a course in integer programming, they'd know the answer was always, you set up an integer programming problem. If it was a course on Markov processes, they'd know that. And here you're just saying, here's this problem. Go attack it.

STEVE POLLOCK: You hit it right on the head, Mark. That was exactly it. And from my point of view as an academic, as a teacher, to me that meant a lot more, because you can always teach the next trick in a non-linear programming problem. You can always teach that. And the students write it down and they'll remember it.

MARK DASKIN: Or not.

STEVE POLLOCK: Or not, exactly. Or forget exactly in what situation do I use that particular technique? Whereas teaching the students and showing them that your job as a professional is going to be not how much you know about the latest algorithm, but it's how much you know about the problem, how much you know about what are we trying to do? How are we trying to solve these problems? What can we throw away?

I won't mention names, but very recently, we were at a very interesting seminar. Somebody gave a talk on a paper. It was very, very interesting. And there were some results that were put up which were sort of interesting results. But something struck me. There was a particular parameter that nobody was sure of. It could have been one of two or three different values. And what we saw was as a result, the statistics associated with assuming parameter one, two, or three value, but the results were to the fourth or fifth decimal point.

Now, here we have a problem where we were reporting out results that should have been to within plus or minus 1. And they were plus or minus .0001. And that removes from the student who's trying to learn about it what's going on, and it's put into the hands of a person who said, oh, I know how to do the statistics. And I'm going to do a beta test, a this test, and other test, rather than why am I assuming this? Where is it coming from? How sensitive is the whole thing?

And it's something that I think we really have to do in OR education. In fact, I think you know you've done a good job if you try to describe a problem to a student, or to a colleague, and the first thing they say is, well, wait a minute. How are we going to go about doing this? Why is that such an interesting parameter? Why do we want to maximize that rather than this?

Good question. And if a student can learn to ask a good question, it's a lot better than answering a bad one.

MARK DASKIN: I think that's absolutely right. I think a key thing is learning what questions to ask, and how to ask good questions, and what data you have. The other thing I've always felt for a while, felt for a long time, and it will display my age as well, is that I think every engineering student should know how to use a slide rule, because 2 times 2 is the same as 200 times 200. And

you've probably seen this. You get answers that are accurate to eight significant digits, but they're only off by two orders of magnitude. And it makes you wonder.

STEVE POLLOCK: Exactly.

7. Most Interesting Problems

MARK DASKIN: So of all the work you've done, all the papers you've done, all the consulting you've done, what are you most proud of?

STEVE POLLOCK: Oh, boy. That is--

MARK DASKIN: One of your most highly cited papers is the one on HIV.

STEVE POLLOCK: Yeah. Right. And that was sort of interesting. I was very proud of what happened, because I came in hoping on a SEIR model, a susceptible infected -- a standard model of epidemics.

And I came in and essentially said, you have rates going from one to the other, but we don't know what those rates are. They're probabilistic. And that was my contribution.

But there were a lot of citations, not because of my contribution, but because it made it easier for people to understand how uncertainty was to put into those kinds of models, which was not, at that time, very prevalent. And so I'm not saying that's the thing I'm most proud of.

Actually, the thing I'm most proud of is something associated with the modeling course. That's when a good friend of mine, who was the head of radiation oncology at the university, was at a cocktail party, and we were chatting about stuff. And he said, "Hey, Steve. You would be interested in this.

We have this problem that we have where we're shooting radiation on tumors, on cancer tumors. And if we miss, we put too much in there, that's bad. It kills healthy tissue. If we don't hit it on board, then we're not going to kill the cancerous tissue.

And the trouble is, we've done pretty good with understanding what's going on when the tumor is sort of static. It's sitting somewhere. But it's almost always changing. It's getting bigger and smaller. The patient has moved a little bit. They have a full bladder, not full bladder. And so it's a lot of uncertainty."

And so I said, "Well, what do you do about it?"

He says, "What we do is we take the tumor and we take its dimensions. And then we take a look at the standard deviation of the deviations as it moves around. And we multiply 1.5 times each of the 3D standard deviations. We enlarge the tumor. We have a bigger target. And the target is what we aim at now."

And I said "Well, OK. That's good." I said, "Why are you asking me?"

He says, "Well, you know, thought you might be interested in that particular problem, because we're taking the standard deviation, and you're interested in uncertainty and so on."

I said, "Yeah, but where'd you get the 1.5 from?"

And his answer was a really great one. He says, "You got a better number?"

And so he was the head of radiation oncology.

I said, "Well, I don't know. We'll try." Went to the course.

MARK DASKIN: 1.51.

STEVE POLLOCK: Could be 1.73. Exactly. Where'd you get it from? Maybe it depends upon all sorts of stuff. And he literally said, "Do you have a better number?" So I gave it to the class, and it was a little bit too much for two, three weeks. Although a PhD student, Lisa Maillart, picked up this problem and helped me work on it, although she actually produced a different dissertation.

And it turns out that one of the worst things in the world you can do is what he was saying to do, because, you know, if you think the tumor is here, 50%, 50% here, just like the tank on the road, OK, you don't aim in the middle, right? And so what should you do? And you say, well, OK. Let's come up with a new representation, in which you try to maximize the probability that you kill the tumor and minimize the probability, or minimize the expected value of the healthy tissue that's being hurt by the radiation.

And it turned out we had some really nice results on that, and it was published well, and used well. And there was a whole lot of optimization going on in it, which I stay away from. But a number of our colleagues worked on it, and it's produced some interesting stuff. So I'm really proud of that.

MARK DASKIN: I looked at that paper last night, actually. And I would say that it's certainly not marginal work, so to speak. If you sort of think about the margins around-- right. Conversation is degenerating yet again.

8. Career Advice for Others

MARK DASKIN: So let me ask you this. What advice would you give to a junior faculty member now, as they're starting their career? Or to a PhD student?

STEVE POLLOCK: I'll give them the same advice that I gave to my sons. Find out what you're good at. Find out what you like. If you're lucky, you like what you're good at, in which case, find out a profession you should be in that would pay you enough money so you can do the stuff you like and you're good at.

Then you've got to talk to people who are academics and find out what their life is like. Talk to them and find out, do they work late at night? Do they play with their kids? Do they not? Do they take time out? Do they enjoy writing papers? Do they not? And if you're not good at any of that stuff, don't do it.

MARK DASKIN: Or don't try it.

STEVE POLLOCK: Yeah. Right. Exactly. If you're smart enough to get a PhD, you're smart enough to figure out where you can make a difference. Go find a company that can use your talents. Go find a friend who's putting together a company that can use your talents.

But the idea that you just march up the steps, you get your bachelor's degree, you get your master's degree, you get PhD, you're an academic, you're an assistant, associate, full professor, it's not automatic. We know people who are assistant professors, who all of a sudden realize, hey, you know, I really like doing this something better than that. Go out and get a good job and you like it.

And I don't know why, sometimes students think it's a failure, somehow. And it shouldn't be.

MARK DASKIN: Well, I think part of that is that, of necessity, a lot of the mentors they have are academics. And they feel like they're letting their mentor down if they choose to do something else. And I think many of us love what we do. And so they feel like, why shouldn't I love what I'm doing?

STEVE POLLOCK: Well, you know, Ron Howard was my thesis advisor. After about a year or so, I kept coming in with these drafts. And he said, "Oh that looks good." He said, "Have you solved that particular thing yet?"

And I'll say, "No, I haven't." He said, "Well, come back when you did."

And then I solved that, but I created another problem. And he would say, "OK. Do this." He says, "Are you done yet?"

And I said, "No, I'm not done yet, because I still have to do this, this, and that."

It took me about three years before I realized when he said, are you done yet? I said, yeah, I guess. He said, OK. Wrap it up. Show me what you have.

He wanted me to say when I thought I had done what I wanted to do. He wasn't going to tell me. And that was tremendously wise advice. And that's what I'd give to the students. What do you want to do?

9. Challenges for the Field of OR

MARK DASKIN: What do you see as the big challenges or problems for the field right now? In some sense, we're very healthy. We have 12,000 members of INFORMS. We're at this

conference with 6,000 of them a year. We've got something like 90-some parallel sessions. So in some loose sense, the profession is healthy. Do you see any warning signs for the profession, or any concerns that you have?

STEVE POLLOCK: No, I don't see any warning signs. But what I like about the institute, or the organization, is that it has enough sub-groups to be able to absorb the various interests of lots of different people. And so there's nothing that's insisting that there is a common thing that everybody has to have, other than, I think, rationality and understanding of technology, the available technology, and understanding what the problems that you're dealing with are.

And to the extent that if all of a sudden, you start lining up and saying, well, that's not operations research. We should not include that in our portfolio. We'll let other people do that. That could possibly happen.

Because I remember when we went from two outfits, two organizations into one. There was some still concern about how do we keep our identity? How do we keep our identity?

And it turns out now, you don't really need that much identity. You can be a member of three or four different interest groups, and so as long as that happens, that's great.

And as long as people can't tag you. I think that may be even the best. As long as people say, well, what do you do? And you say, I do a little bit of this and that. I solve these kind of problems, you know, criminology and military and harvesting crops and so on. And people say, there's nothing in common with all of that. You're right, except these are problems that need to be solved.

So I don't see a direct threat. The only thing I can think of is the word "analytics" is something has always bothered me, because it's just another name for, I think, what we've always been analytical. And I'm not quite sure whether that term is still hanging around. Is it going somewhere? Is it grabbing something? It's just something that I think we should watch and make sure that it's OK, make sure we're not trying to divide things up.

And the other thing is, I still think statistics departments and operations research departments should work closer together. As long as people say, no, no. We do this stuff. We will allow somebody from the other kind of department to get involved, but not too much, because we-- that's bad, too. I think there should be a lot of correspondence there.

MARK DASKIN: I would add computer science departments, these days, too.

STEVE POLLOCK: Certain aspects of computer science.

MARK DASKIN: And we have people who bridge those gaps.

STEVE POLLOCK: Right, and that's great. And what's great is when you see medical schools, operations research departments, statistics departments, working together on a single problem. That's great. As long as we do that, I think we'll be really healthy.

MARK DASKIN: Well, maybe that's a good place to close. But if we're going to close there, I will add one plug for our students, who won the Doing Good with Good OR award for their work with Brian on urology. Anything else you wanted to add about your career, about the profession?

STEVE POLLOCK: The only other thing I can think of is that something that we're not very good at, from a pedagogical point of view, we very rarely stress objective functions, identification. It's almost always given to you. We want to maximize this subject to that.

Now we spend a term worrying about it, rather than spending a week or so saying, well, why do we want to maximize that anyway? And again, I could give you lots of anecdotes, real-life anecdotes, which I won't bore anybody with.

MARK DASKIN: OK. Thank you very much.

STEVE POLLOCK: Thank you. This was great.