# Zvi_Drezner Interview by Stefan Nickel, November 4, 2018, Phoenix, AZ

## Early Life

STEFAN NICKEL: So welcome to our interview with another famous operations researcher. Today I have the pleasure to interview Zvi Drezner. And maybe first we start about your background, family, when you were born just that people know a little bit about your personal details.

ZVI DREZNER: OK. I was born in Israel in 1943, so actually before the establishment of the state. My parents were from Poland in the border of the Ukraine. They emigrated to Israel. And all my education I did in Israel. From early childhood, I loved math, physics and astronomy. So I wanted to be a mathematician.

And I actually won some prizes. In the last year of high school, there was a nationwide competition in math, and I won first prize. And later, there was a radio program, it's before TV, about astronomy, and I also won first prize. The prize I won for the math at high school was sponsored by the Technion and the prize was four years tuition free in the Technion. So I did my bachelor's degree in math in the Technion.

Then I had to serve in the army. And that's a mandatory service in the army in Israel. And since I wanted to do a professional career in the army, I had to do it for five years rather than three. And I was assigned to the newly established computer center in the army. I had a lot of projects. I learned programming on computers in machine language and more advanced languages like Fortran. At that time, it was not called Fortran, but it had the same idea. I had many projects in the computer center. Five years is a long time.

Many of the projects were top secret that I shouldn't necessarily talk about. But one of the projects at the end of my service was to design a new army base. So they gave me information about 57 buildings. And they gave me a long list of pairs of building that need to be close to one another. And they gave me a ranking from one to 10, how close they need to be to one another. They want me to create a layout so that the buildings will be in the right layout. They told me that an architectural firm is working on it for a few months and they could never come up with an arrangement that is satisfactory for the purpose.

So, knowing nothing about operations research, even the name I didn't know. I was thinking of myself as a mathematician. And definitely I didn't know anything about layout, the layout problem and methods to solve it. So I looked at the problem and I said, let's suppose that the buildings are circles. And every two circles that need to be close to one another are connected with a spring. And if the need for it to be higher, it's a stronger spring and a weaker spring. Many pairs of circles have no springs at all because they had zero requirement. And then I said if I toss it, maybe it will come up with an arrangement that those that are connected with strong springs will be close to one another because the springs will pull them together.

So it didn't work that well, so I decided to put all the circles in one point and let the whole system explode. And once the system exploded, I stopped the explosion and let the circles come back; all those done with the springs attached. And I got a configuration. And lo and behold, all the buildings that need to be close are close to one another. They gave it to the architectural firm and they were delighted. They couldn't believe it can be done.

I was, at the time, registered for a master's degree in the Technion. So I talked to my advisor, and I said, I have here a nice problem. Can I do a thesis, master's thesis, on this problem? And he said sure, so I wrote it down. And I went through the defense of the master thesis. And there were three professors, of course, the committee.

Once I finished the defense of my thesis, I had to go out and then they called me back in and they told me, Zvi, this is not a master thesis. This is a PhD dissertation. So they said, we will convert this master thesis defense into defense of the PhD proposal and you will submit the same thing after we finish the paperwork and get your PhD.

And the funny thing is that I called my wife and I said, that's what they offer me. I'm not sure I want to take it. I will not have a master's degree. So she on the other side of the phone said, you must be out of your mind. Take it! And I agreed. And then after less than a year, I got my PhD on the same layout problem. They had to call two more professors, because a PhD committee is five and a master committee is three.

The criterion in Israel for a PhD dissertation is that it's publishable in the top journal in the field and the committee feels that it's suitable for publication in the top journal in the field. And later on, I wrote the main contribution of the paper and submitted it to Operations Research, which is the top journals in the field, and it was published. So the committee members were actually correct in their assessment if it's publishable in the top journal in the field. And that's how I got my PhD.

STEFAN NICKEL: So was it a PhD then in mathematics or in computer science or in OR?

ZVI DREZNER: OK. It was in the math department. And then they said later, before I got the degree, we just established a computer science department. Would you mind to be the first PhD of the computer science department? And I said, OK. So my PhD is in computer science. And that's the story.

Now, a side comment. I must say that had I known OR if I went to the traditional way that they do it in the US and in many other countries in the world, I would be forced to learn all the papers on the subject matter and so on. Had I known OR and I knew the layout problem, I probably would have used one of the available ones which was much inferior to actually what I was able to come up with, because I didn't think of it as an algorithm. The whole process was solving differential equations of the physics of the explosion.

Now, one of my colleagues in the army said, call it the big bang method. It's like the big bang. But my advisor didn't like it and he said, we need a sexy name for it. So we called it dispersion concentration, and it's called DISCON. And it's published in OR in 1980, the DISCON method.

So that's how I got my PhD. And that's how I was introduced into the whole area of OR. And I think in many ways until today I see myself as a mathematician. I do OR because those are the problems I am interested in happens to be in OR. Most of the problems I'm working on.

STEFAN NICKEL: OK. So you think it's a good development if one starts with mathematics and then converts to OR? Are there other ways to?

ZVI DREZNER: Yeah, I tell many people, students, whatever, that a bachelor degree in math is an extremely important bachelor degree to continue to many other fields. The best bachelor degree is in math. If you have a good math foundation, it will help you in many fields, it will not help you in history, OK, but will help you in operations research and engineering and everything you can do.

STEFAN NICKEL: So what have been your major topics in the math studies since you didn't have OR? So do you remember a little bit what were your favorite math topics?

ZVI DREZNER: Yeah. When, I studied for my bachelor's degrees, I was fascinated by two topics. Matrix theory, actually. I couldn't believe the Cayley-Hamilton theorem. I couldn't believe it can be true. I mean, it was so counter intuitive to me. And I was also very interested in complex numbers. The whole theory of complex numbers. And I never saw complex numbers used in OR.

I have one paper about how to find if a point is inside a polygon or not. You add up the angles. If they are 2 pi, it's inside. If they are 0, you're outside. But the proof for this property I use complex numbers with the pole at that point. But I wish I had a problem that complex number theory could have been used. But I don't know. Those were the two topics. And I love numerical analysis from day one.

STEFAN NICKEL: OK. So numerical analysis was also part of it.

ZVI DREZNER: Yeah. And many of my papers involve solving differential equations. That's my math background.

## Beginnings of Location Science

STEFAN NICKEL: So this is how you also started to do location theory or location science, which is where you are very well known to be a very productive researcher in location science. So how did you really convert to be a location scientist and how did you come to the US? I mean, this would be very interesting.

ZVI DREZNER: The title of my dissertation is The Location Allocation Problem. Because neither of us in the math department knew about layout. And that's a wrong name, but that's the name of my dissertation. Then I looked for a postdoc. So I look for people who did location. And George Wesolowsky from McMaster University in Canada offered me to do a postdoc with him. And he was a main person in location theory at the time. So that's actually how I started to do location. George was an excellent person to learn from, and he taught me how to write papers. I didn't know those things.

I came to McMaster and in the first meeting I had with George, he gave me two problems. I don't even remember what they were. And the next morning, I came with the solutions to the two problems. And he was in shock. He thought that these two problems will keep me for half a year or six months. And then he was constantly complaining that I give him work because he has to find problems for me. He gave me two problems. I solved them.

In the two years of the postdoc, I think we wrote some 15 papers with problems that George, most of them were George Wesolowsky's ideas about location. I think the first problem he asked me is to find the probability that if the weights in the location problem are random, that the solution will be at a certain point. So I came next morning and I gave him the expression for the probability. So that's how I got into location. I have to thank George Wesolowsky for that.

Then most of my papers, I don't know if I should say how many papers. I have over 300. But most of them are on location theory. But I have a lot of papers in statistics and inventory control and many other topics. I meet with people in conferences and so on, and then we discuss an issue. And the issue may or may not be location. And I'm usually the resource person to solve the problem that we come up with. I have a lot of papers with my wife that her interest is in competitive location. So I know programming better than her, so I usually write the programs to solve the problems that we come up with. Now I have four papers with my daughter.

STEFAN NICKEL: That sounds good.

ZVI DREZNER: Yeah. She's a geographer. She actually is an ecologist. And we just chat and I said I do genetic algorithms. So I know she got interested in doing genetic algorithms. So she had ideas from ecology that we implement in genetic algorithm. I have an older paper with my wife that we discussed on coffee at Starbucks.

I told her what I do in genetic algorithms. So she said, why do you select any two members and they mate and produce an offspring. It doesn't make sense. One has to be a man, one has to be a woman. So we developed a genetic algorithm that is gender specific that half of the population is males, half of the population is females and you mate only males and females.

And with my daughter, she has her ideas. For example, when I told her about male and female, she said there are many animals that are alpha males. That you have one male and many females, the dominant male. And I said, oh, that's an idea. So we have a genetic algorithm based on the alpha male. It's now in print. No, not published yet, but the galley proofs were done.

And that's actually works very well. We select, let's say, out of a population of 100 only 25 males and 75 females. And the imbalance seems to help the genetic algorithm. And my daughter added a long literature review from biology about alpha males. I didn't know that bees have an alpha male thing. I mean, I read her literature review. I see a lot of things I don't know.

STEFAN NICKEL: But so your favorite location theory part was always continuous location, right? Is it because there's more mathematical structure?

ZVI DREZNER: Absolutely. Let me say that in location, there are two main streams. One that deals with discrete location, which means that you have a list of potential locations for facilities and one that you can locate facilities anywhere. That's called continuous. Now, the discrete location problems, I am sorry to offend people who do discrete, are easier to solve, because you have to select from a given set of locations.

In continuous in most cases, you are free to select anywhere. And it turns out that mathematically, it's more complicated, so my interest is basically in continuous. I did also discrete, but most of my interest is in continuous facility location. Well, the method used in order to solve it may involve differential equations, may involve math other than an algorithm that's already known.

And nowadays, people especially who do discrete, use CPLEX, use MATLAB, use those software that are…. You have to formulate the problem. You formulate it with constraints, integer, binary, or non-integer, whatever. Then you throw it on CPLEX or MATLAB, get the answer, and have a paper. In my papers, most of them, not all of them, I write my algorithms in Fortran, of all things. And Fortran is much faster and much more flexible than CPLEX or MATLAB for all those problems and programs.

I remember when we hired a new faculty, and I said I write in Fortran. He said, nah, I write in Java. It will take a month and one day to complete. For me it will take one day to write the program and one month to run. For you it'll take one month to write it and one day to run. I said, OK, it makes sense. You want to do the program for our paper? He said, yeah. And I didn't like it. The times were unbelievable, he could solve only small problems.

So I said, OK, let me try it in Fortran. It was a Tabu Search thing. And I wrote it in Fortran probably in a couple of hours. Probably more. I'm exaggerating. But not more than a day. And it turns out my Fortran code was 35,000 times faster. I'm not talking about 10 times faster. 35,000 times faster. What took him more than a day took me three seconds. That's 35,000. And I checked what's going on. I mean, it cannot be that much.

I think I can say as an example, not that it's the whole thing. Let's say in the process, you have to add up 1,000 numbers. So what do you do in Java and CPLEX and whatever, you write sum of the vector. Now, when I do Tabu Search or descent or so, I have the sum of the vector. But I change only one number. So what I do in Fortran without thinking, it's not even intentional, I subtract the old number and add the new number. In Java, he added the 1,000 numbers each time. So no wonder the ratio was that high.

I must say, it helped me to publish papers, because my run times are so much better than everybody else's. But sometimes gives me a problem because the referees don't believe that I report the correct run time. But it never occurred to me to cheat on those things. I don't know. I don't need to, basically.

## Paper Productivity

STEFAN NICKEL: So before we continue with your academic life, we get lost a little bit at the papers, but it does matter. But you are not only known for writing fast codes but also for fast writing papers. So do you know what is your average time you need to have a first draft of a paper ready? I experienced some. It could be a few days or?

ZVI DREZNER: First of all, I need to have an idea. Then I write the introduction. Then I write the program. The program may take a week or even a month to run on the computer. And then I write the paper once the program is done and I have results. Because before I have the results, I don't know which one will work better. I try several options and so on. So, for the introduction, I am familiar with the literature. Doesn't take me that long. And then after I write the algorithm down and the program's completed to write the conclusions and the computational experiments and so on, it doesn't take me long either.

But my writing is not good. I mean, I write and then I read it and I read it probably 20, 30 times before I fix all the sentences and so on. But nowadays with word processing and LaTeX and all those things, I can afford reading it 30 times without investing too much work. So it works very, very well. And I think the final product is good. But the initial product, I change all the words in the sentence. I'm not good in writing. My wife is very good at writing.

STEFAN NICKEL: What would you think is your fastest paper? So how long did it take you to write it? What would you say? Just to get a benchmark for young people.

ZVI DREZNER: I have a note of two pages. I can tell about the note. That took me probably an hour.

But it's an interesting note. I have a problem in programming when I do Tabu or all those things. You have to select the best one. You do check a lot of permutations. You have to select the best one. What do you do if there is a tie? So, what I used to do, I would make a list of all the tying and then choose at random. Another way is to go in random order. And let's say I choose the last one. But since it's in random order, I can choose the first one, I choose the one at random.

Now, I was thinking, I said, that's not efficient. So I came up with the idea that if I get the best one, I select it. That's k equal 1. If I have a second one tying, I select it with the probability of 1/2. If there is a third one, I select the third one in probability of 1/3, 1/4…. So, if there are K tying solutions, then each one is selected with probability 1 over K. So I thought, I don't know, that's simple.

I met Fred Glover at a conference and I told him what I did. And he was in shock. He said, all my life I was wondering how to do it, and what a great idea. I'll tell it to everybody. So I said, if Fred Glover is so excited, I wrote it down with the theorem that proves that it's 1 over K. Submitted it to Transactions of the ACM, and it was published. The referees liked it and it was published. So if you asked about the shortest time frame.

## Academic Career

STEFAN NICKEL: That's really interesting. But let's go back to your academic career or your development. So we were with George Wesolowsky. These were your first years.

ZVI DREZNER: Yeah, for a postdoc.

STEFAN NICKEL: But there had been much more stations in your academic life.

ZVI DREZNER: Yeah. Then I spend seven years in Michigan. Now I'm in California, in California State University Fullerton. And I like it very much. Simply, I enjoy California. and the school is really supportive, and I like it. And that's since '85 I am there. Now I am retired. But I still teach a couple of classes every year or two. I don't want to do nothing. I'm afraid that if I will do nothing, then I'll deteriorate.

STEFAN NICKEL: So which classes are these?

ZVI DREZNER: Operations research.

STEFAN NICKEL: So supply chain or location theory? No?

ZVI DREZNER: No, we don't have a specific location class. I use location theory examples in many of my classes. But I still write at the same pace I was writing all the years. I didn't slow down. And that also helps in my mental ability, if you want to call it, or sanity.

STEFAN NICKEL: So you also enjoy teaching? I saw in your CV that you have many teaching excellence awards from Fullerton also.

ZVI DREZNER: Oh yeah, I have a lot of excellent teaching awards. I remember the associate dean gave me the teaching award and the associate dean read a few comments from students. And one of them I thought was not good, but everybody was so happy with it. That a student wrote, I wish he was my uncle. I thought it was an insult. But everybody else thought it was a very good comment.

STEFAN NICKEL: Because it's also operations research is not known for being a good candidate for teaching awards.

ZVI DREZNER: I have a lot of students that came to me and said I was afraid of the topic and I am forced to take it. And after I took it from you, I switched my interest into OR, which gives me a lot of satisfaction when student tell me that.

STEFAN NICKEL: Do you have a trick or a special tip for others how to do it simple?

ZVI DREZNER: I try to make it as simple as I can. And so my theory is, if I make it difficult, people will never use it. If I make it simple, there is hope they will use it because they will not be afraid to use it. So I teach with a lot of examples.

And interesting that you ask. I never thought of that. But when I applied for those awards, I have to write my teaching philosophy. I hate those things. So my teaching philosophy is, honestly, when I get to a new topic, I start with a few examples. And once I finish with a few examples and explain, then I explain the theory.

Most professors start with the theory. The students are lost. They cannot handle it. And then they do examples. I start with the examples, then when I do the theory, they can think of the examples and relate the theory to the examples. I think that's the main reason I have such good students evaluation, because the students can relate to the theory after they saw the examples.

STEFAN NICKEL: Great. So if you have your academic life, you usually have also academic treatment also. So probably can you tell us a little bit about which good academic children you had or whom you awarded PhDs where they went?

ZVI DREZNER: Yeah. Unfortunately, Fullerton doesn't have a PhD program. So I was on committees of PhD students, but I don't have my own PhD students. I basically work with colleagues. And I have, I counted, I have 95 co-authors.

STEFAN NICKEL: And over more than 300 something papers. That's really impressive.

ZVI DREZNER: Yeah. With colleagues in Fullerton and people all over the world. From Japan, from Chile, and Germany, of course. And I can make a list of many countries that my colleagues are from. And many of my co-authors are dealing with location. I have a lot of questions that came up that has nothing to do with location, and I am still intereste. My most published paper, over 2,000 citations, is a paper with David Simchi-Levi. And he is now the editor of Management Science.

It was in a conference, my wife reminded me, in San Francisco. We were sitting down and David said, I have a problem only you can solve. OK. What's the problem? So it was the bullwhip effect. And so he gave me the problem. I said, what is that? So I'm not familiar with that thing outside my area, OK? So explain what it is.

And he said, can you develop a formula for the ratio of the two variances and so on? So I said, OK. David said the next morning, well, I think it took me a little bit longer than that. I came up with the formula.

He with his PhD student wrote the paper and I gave the analysis of the formula. And it was published in Management Science and cited more than 2,300 times. 0 times by me, because I don't do those things.

But it was 2,300. I don't remember the exact number. It changes every day. Over 2,000 citations. It's interesting that it's his most cited paper and my most cited paper.

## Most Interesting Papers

STEFAN NICKEL: So when we talk about papers, are there a few more, maybe your three papers you are most proud of? Is there something like that? I don't know. It is sometimes not the most cited one.

ZVI DREZNER: Yeah. This one is not in my area, so to speak. But one paper, it's from '82. In '81, there was the ISOLDE conference: International Symposium on Locational Decisions, I think, which takes place every three years. '78 was the first one and '81 was the second one in Denmark. I hosted the fifth one in Fullerton in 1990. And Lou Hakimi presented the issue of competitive location on a network. He does networks. You have several competing facilities and you have customers and you want to put a new facility that will attract the most customers.

So I was sitting in his presentation. I was fascinated. So I wrote a paper in the plane of the same thing. And then, without knowing, I also solved the problem if I want to put a new facility to protect against future competition, where should I put it? So I submitted it for publication and the review came back, why don't you mention the Stackelberg equilibrium? And I didn't know about it. So the paper now has Stackelberg equilibrium. And that's a paper that was one of the first papers in competitive.

And then when my wife did her dissertation, she asked me, do you have any idea? So I told her about a few papers, and she got hooked on the competitive. And I gave her the paper and then she elaborated on it and extended it and that's her dissertation on competitive facility location. So I am very proud of this paper because of the consequences.

STEFAN NICKEL: And I would say you influenced a lot of people. I mean, we were talking about academic children. It doesn't mean that it's yours, but you influenced a lot of other people studying--

ZVI DREZNER: It was the impetus for her dissertation because she was looking for a topic. And this topic she liked. Now another paper. There is another thing that I like. It was also not published that many times, not cited that many times, but I like it, and that's the trajectory method. And whenever I tell it to people, they think it's very neat, and I also think so. We have the basic, very basic location problem, the Weber problem, which is finding the location that minimizes the weighted sum of distances to points. The first one who dealt with it was Fermat 400 years ago, the famous French mathematician. And then Weber, Alfred Weber, published a book in 1909. So we call it the Weber problem.

And there are methods to find the best location. And it's convex, so it's relatively easy. Now, the solution for the same problem but the weighted sum of the squares of the distances, is very simple. It's the center of gravity. So I asked myself as a mathematician, what about the problem of the weighted sum of the distances to the power of lambda? Now, for lambda equal 2, I know the solution. For lambda equal 1, I want the solution. So if I change lambda continuously from 2 to 1, I get a trajectory of locations. And then the end point is the solution I am looking for.

Now, it turns out that to calculate a trajectory, it's a set of differential equations, and I am not afraid of that. So that's actually published in Management Science also. But that's kind of a paper I am fond of, because I think it's a very neat idea. Well, people are not using it that much, because they seek a solution of partial differential equations. No, it's not partial. It's differential equations.

They get scared and they don't feel that they are competent enough to apply it to other things. Because I have also the same idea for two more problems that also changing the lambda and moving from one solution to the other by tracking the trajectory. So that's a paper I like. I think it's neat.

Now, more recently, I have developed a lot of interest in the quadratic assignment problem. And I have many papers on quadratic assignment problems. And one of my first papers on that was solving it by genetic algorithm. And it was published in 2003 in INFORMS Journal on Computing.

The main issue in genetic is how to merge the two parents. You take two parents and you have to create an offspring. So people take a random selection from here, random selection from there, and meld them. And random doesn't work very well. You don't exploit the special structure of the problem.

So I designed a merging process. I simply took an imaginary line and I took locations of facilities from one parent right of the line, a second parent left of the line, and it created an offspring, did a little descent on it to correct, and it turns out that it provided much, much better results than anything available in the literature. And that's also a paper I'm pretty proud of. And this paper was cited a lot.

STEFAN NICKEL: But this is also a little bit like coming back to your PhD topic, in some sense. Quadratic assignment is layout also.

ZVI DREZNER: Yeah. So you asked me for papers I like. I have so many, it's difficult for.

STEFAN NICKEL: Did you try with a QAP approach to solve again this problem with the 57 buildings from your master's thesis which granted you also PhD?

ZVI DREZNER: The difference between layout and quadratic assignment is that in quadratic assignment, you have, let's say, a square or a rectangle five by six, 30 locations, and you have to assign a facility to a location. In the layout and in the original 57 building, I didn't have a structure. They didn't force me to a square.

We have 57 buildings. Some of them are bigger than others. So I took bigger circles than others. And if you have an empty space between circles, we'll put grass there. I mean, they just want the general arrangement. So I never tried that in quadratic assignment, because 57, it's also will not give me a rectangle anyway.

STEFAN NICKEL: Yeah, that's true.

ZVI DREZNER: I'm not sure I even have the data.

## Obnoxious Facilities

STEFAN NICKEL: OK, good. So these were the most interesting. We found three papers, right?

ZVI DREZNER: Yeah. There is another paper that I want to mention. It's now in press in Omega. And that's a multiple obnoxious facility. Obnoxious facilities also are interesting to me because it's more mathematically involved.

So suppose you have 100 neighborhoods in 10 by 10 miles, or 100 by 100 miles. No 100 by 100. miles. You have 100 neighborhoods. You want to build 20 facilities. But those facilities are obnoxious. That's a term that Rick Church coined.

They produce nuisance. Produce pollution, produce noise. Airports even are included in that category. But basically factories that have smoke and noise and so on. So in the obnoxious problem, you want to put the facilities as far as possible from the demand points.

Now, if you don't put limitations, and let's say I do it in Orange County, California, the best location for the obnoxious facility is in New York, let's say. So you have a restriction. It has to be in the area. So we want to maximize the minimum distance to the closest demand point. So if you have 20 factories, then the solution will be to put all of them at one point. And that's not acceptable, because then the pollution is magnified. So we formulated, let's say, you want at least 16 miles between facilities. And it's 100 miles by 100 miles.

So my colleague Pawel I mentioned before said, oh, MATLAB will do it. So he formulated in MATLAB. It took him probably five minutes. I don't know. It's not a complicated formula.

And he ran it from 1,000 random solutions. I think 1,000. And he got a solution that the minimum distance, I remember the number, it's recent, 0.38 miles. And I said, there must be a better solution. But OK, he said 0.38 miles. It took five hours on the computer.

So I looked at it and I said, if a facility is located inside the triangle, the minimum distance to the three vertices of the triangle is called a Voronoi point. So I say, why don't we locate the facilities at Voronoi points so they will choose big triangles? So OK, that turns out to be a simple binary linear programming. Because you either select a Voronoi point or not. And for the 100 points, there are, I remember, 202 Voronoi points.

So we formulated a simple binary programming that you select the best Voronoi points that are at least 16 miles from one another. And Pawel came back and I couldn't believe we got solution for over four miles. Which means the solution is more than 10 times better than the Voronoi. And it took 24 seconds. It was not in Fortran, in CPLEX. 24 seconds.

So we submitted it. And probably the referee couldn't believe it. That instead of five hours we did it in 24 seconds and more than 10 times. And we did a lot of examples and we submitted it. So it was rejected. Not rejected. It was major revision. The referee said SNOPT in MATLAB is better than what he used. So we used SNOPT and SNOPT gave us a mile and a half. So it's better. But still, the solution is of four miles. So we submitted it with SNOPT and it was rejected.

So we submitted it to another journal. I don't want to name journals. I don't want to offend anyone. We submitted to another journal and the other journal wanted a practical example. Major revision, not to generate randomly. So I looked at the map of the US and I looked for a state that is rectangular. Because I didn't want to have problems in delineating.

And Colorado is rectangular. And Colorado has 271 communities in Colorado. So we solved it for Colorado, and we solved it in the original interior point in MATLAB. In SNOPT and by our method and our method was much better and so on. So we submitted the revision to the journal. Rejected.

So we submitted to a third journal and now it's accepted. The third journal was Omega. And I can say because they accepted it. But it was rejected twice after revision. So what I say to myself, if we took the problem and did MATLAB and submitted it for publication. By the way, SNOPT took the same five hours. It was the same time, but the result was better. Probably it would be easier to publish.

Now we submitted it with MATLAB and the Voronoi thing. So the referees either didn't believe us or it destroys their point of view of the world, because all what they do is formulate, throw in MATLAB, and have a paper. So if you submit it originally in MATLAB, it probably would have been published. And nobody will know that there is a solution of four miles.

So let's say, MATLAB, it was 0.38 miles. The best of 1,000 random starting solutions. And then, I guess it would occur to us, SNOPT. We could have a follow-up paper doing it with SNOPT and get one and a half miles, and more than four times improvement at the same time and we had a second paper.

STEFAN NICKEL: And the third paper with the Voronoi.

ZVI DREZNER: Could have been this one. And the mold that I see in operations research these days is more of the type. I come with a somewhat new idea. I formulate it. I may change things here and there. Drop it on a nonlinear solver and get a paper. People are not thinking outside the box. I don't know. The Voronoi point idea was I guess a good one, but people are not used to.

And I believe partly because the way we teach our PhD students. We force them to learn the literature. If I had my PhD in the conventional way in a US university, I will have the problem of the 57 building. I will know there is a layout. I'll do it and it will give me bad results, but who cares?

I will not be forced or inclined as a mathematician to try and solve it without knowing the literature. I think the way we trained PhD students, and maybe it's correct for many of them, inhibits innovation. They are taught, all of them, to think the same way and not look outside the box.

STEFAN NICKEL: But it's also a little bit like looking for structural results instead of for only faster run times. I mean, the Voronoi approach means you look at it in a structurally completely different way. So it's more a mathematician approach, in some sense.

ZVI DREZNER: It's not only that. I'm not only proud that I did it in 24 seconds instead of five hours. But also the result was much better. When I talk that I do Fortran, if somebody will do it on SNOPT and so on, we may get the same result, but mine will be faster. OK. But here the whole approach was innovative.

That's why it was rejected from two journals after revision. Because people cannot appreciate innovation, I think. It's not only in OR. It's the whole refereeing process that referees look for things similar to what they are doing. And if you do something outside the box, they cannot relate to it. Yeah.

I never asked Fred Glover, but his Tabu search, the original paper was published in EJOR. At the time EJOR was not a top journal like it is today. At the time, EJOR was just established. And you send out a paper that was quite a high acceptance rate and so on. I want to ask Fred Glover, is that the first journal you sent it to?

I have a feeling that he thought it's a good idea, blah, blah, blah, and said, if I think something is a good idea, I will send it to Operations Research. If I think it's OK, I send it to a lower journal. So I find it hard to believe that Fred Glover started with EJOR as his first submission. Because people say Tabu search? Prove that. And those are the comments you get.

With the Voronoi, the referee said if there is a large area which is void of communities, you may be able to put two facilities there. But they are not Voronoi points. So in our reply to the referees, I said, but ours is a heuristic anyway. So I don't prove optimality.

Actually, because of those comments, we proved that for p equal 2, 3, 4, and 5, our solution is optimal. We could show it. But if it's presented as a heuristic and it is a heuristic, he found an extreme case that it will not be optimal. So I said OK.

STEFAN NICKEL: This is why it's a heuristic.

ZVI DREZNER: After all, it is a heuristic.

## 75th Birthday Celebration

STEFAN NICKEL: Thanks for the insight on the papers. So just to come to an end, you just turned 75. So you are in the middle of your academic life. Just maybe some comments about will there be some celebrations or some activities for that? And what are your plans?

ZVI DREZNER: Yeah. Two colleagues that are not in the conference, H.A. Eiselt and Vladimir Marianov, offered me to have a book in honor of my 75th birthday that was last February. I gave them a list of my 95 co-authors and many of them wrote chapters in the book, mainly on work that they did with me. And the book is almost done. And it will be, I guess, sent to Springer in the coming month or so.

STEFAN NICKEL: That's a good birthday present.

ZVI DREZNER: Yeah. So I have a 60 page chapter saying how I got my PhD and most of the things that you were talking here. And I summarized most of my papers. And I hope it will be an interesting book to read. Oh, it's totally outside of location. There is the big bang theory that the world started forming at one point and so on and so on. So I had an idea if you assume that the speed of light is slowing over time. Then, if on the spectrum, the lines were generated in a higher speed, there would be a shift. A red shift.

So I calculated that the speed of light has to decline by one kilometer per second every 60,000 years to explain the red shift. So I submitted it to a Physics journal. And they said it's too speculative. I said, that's a replacement to the big bang because it explains exactly the same thing. Too speculative. We don't publish it. So eventually, they recommended I send it to a journal called Speculations in Science and Technology. And it was cited 0 times. Nobody knows about it. It was published in '84. So it will be cited the first time in my chapter.

So I have a lot of papers that are outside my area. And my main difficulty with those papers is to write the lit review in the introduction. That's why most of those papers have a co-author that does the lit review. They are familiar with the literature. I have papers in finance, in statistics. I can make a long list of many areas that I have papers in.

STEFAN NICKEL: So those are people who found some questions or answers missing in our interview can read the book chapter, right?

ZVI DREZNER: Of course.

STEFAN NICKEL: And they get the final answers.

ZVI DREZNER: Yeah. It reminds me of another paper from 30 years ago. There is the binomial distribution. And we call it the correlated binomial. A faculty member asked the question and said: students' grades on exams don't follow a normal distribution. Multiple choice, let's say. It's not normal. You have a lot at the top, a lot at the bottom, and a cello in the middle.

So we came up with the idea, I think it was my idea, that you have an event, let's say 70% chance. For the second event the percent chance is higher if the first one was a success. And it's lower and if it was a failure. And you keep going and you compare the rate of success to the original 70%. And you get a distribution. We call it a correlated binomial distribution. And it turns out that there is a correlation factor. It's not really a Pearson correlation. But if the correlation is more than 0.7, it's bimodal. And then I have a paper proving that up to 0.5 it is normal.

We took the baseball number of wins in the baseball season. There are 162 games, and the average is 81. P is 0.5. However, if a team is winning, it's usually better quality team, then they will tend to have - the distribution is not normal. And that's an example in the paper.

Then in the subsequent paper that we did some improvement, we did the basketball games. Then I took actually 2,000 exams of students and the distribution was fit. You put the correlated binomial and you put the dots and they are very close and they are very far from the binomial.

So a finance professor came with the question, he said mutual fund performance. Is it random or does it depend on the skill? Is it random or skill of the person who do the... We found out that it's skill. It's not random. The data fit the correlated binomial and didn't fit the binomial. So I'm giving you examples outside location that I have quite a few of those.

STEFAN NICKEL: Great. OK. So thanks for the insights and thanks for the interview, Zvi.

ZVI DREZNER: Thank you for asking those interesting questions.