Tim Lowe Interview

Chapter 1 – Introduction, Early Life, and Family

KURT M. ANSTREICHER: I'm Kurt Anstreicher. It's October 30, 2019. We're here today in Iowa City with Tim Lowe, a longtime faculty member at the University of Iowa and INFORMS fellow. We're here to talk about Tim's life and work in the field of OR. So to start, Tim, can you tell us a bit about your family background? Where were you born and where did you grow up?

TIMOTHY J. LOWE: Yes. I was born in Marshalltown, Iowa, which is in the middle of the state, a town of about 20,000 people. I think one of the good things about Marshalltown-- there were a lot of good things, but one of the things that is really important to me was a great educational system, the grade school, the high school, it was terrific.

KURT M. ANSTREICHER: And tell us about your family, your parents, siblings.

TIMOTHY J. LOWE: Sure. Two brothers, an older brother who was an engineer, trained as an engineer, got an MBA, in fact, here at the University of Iowa. Worked as a controller for a major company. Passed away early, unfortunately. Roger passed away.

Younger brother, two years younger than me, also a faculty guy. He was a biologist-- is a biologist, in fact, PhD biology. He's retired, but he continues to work. And he's one of these people that -- he's retired, but he doesn't get paid, although he does -- he does get work on grants.

Every summer he teaches a course up in Northern Michigan. It's a field course, and it's his favorite thing to do because he likes to slosh around. He's a marine biologist, always wading around somewhere, looking for little two-celled animals which are called diatoms. So he's in hog heaven up there when he gets a chance to do that.

Our parents-- my father was a-- he's passed away. We lost both Mom and Dad. My father was a supervisor for a utility company and a very handy guy, extremely handy guy. I think the amazing thing about him-- and I don't know too many parents that do this, but he actually built our house himself with friends from work.

I remember when we were renting a home sort of on the north side of Marshalltown, and I remember he'd take the three boys with him over to where the new house was going to be. And he leased a bulldozer, and he dug the hole for the basement, and then he laid the block. Then he framed the house. He did the plumbing himself with friends, and then he did the electrical. I mean, he did the house. I don't know if people do that anymore. But he was an amazing, amazing guy.

And one of the nice things about his job-- and this will come up later as we talk about some of my hobbies, I guess. We're going to do that at the tail end. But as I said, he worked for this utility. And at the utility, they had these things called line trucks. These are the trucks with the-- they have a boom on the front, and the linemen go out and they climb up a pole and fix wires or whatever.

Well, where they kept the line trucks, they also worked on the line trucks there. So they had-- and they would allow the employees to come and use the garage. So if something was broken down, we would take the car down there and they had a pit where we pull the boards out and you get under the car without lifting it. They had a lift. They had parts washers, they had tools of all sorts.

And for us that was important because the family car, things would go bad. But three boys with these old cars that we used to drive, there was always something that needed work. So it seemed like every week we were down there working on a car.

Now, my mother. My mother was a schoolteacher, not practicing schoolteacher. When we got a little older, she stayed home to take care of the kids. But she was the person who really drilled the importance of education into the boys. I mean, it was almost over the top. I mean, we were willing people. We were interested in school, we liked to go to school.

And one of the sort of funny-- I think a funny thing is a lot of my classmates would get-- if they'd get an A, they'd get $0.25. They'd get a reward at home. So I can remember coming home and whining about that to my mother. I said, come on. Everybody else is getting $0.25 for an A. She says, we're not going to do that.

So instead she would reward us with an attaboy, pat on the back, and then make a cake for us or something. But it was really important-- I think back about that. It was really important to sort of drill into our heads the importance of education, and you don't do it for financial reward. You do it more for life. You're doing stuff to prepare you for life. So that's pretty much sort of my hometown and the sorts of things that were going on there.

KURT M. ANSTREICHER: So I know you went to school in Marshalltown. What subjects were you good at or interested in school?

TIMOTHY J. LOWE: Well, that's actually two different questions, and I'd phrase it that way. I really enjoyed mathematics. I enjoyed-- we had a course in physics. I didn't do so well in physics, but I liked it. I liked it because it involves mathematics. Chemistry I liked. I liked the chemistry course. So those are really sort of the courses that I really enjoyed, and I think it sort of prepared me for the next leap forward, I guess.

KURT M. ANSTREICHER: So was there anything in school that you think influenced your eventual choice to work in OR?

TIMOTHY J. LOWE: Well, OK, so the way I guess I would answer that is in high school, no, because I didn't know anything about OR. I didn't even know what the name was. But I liked puzzles. And I always tell it-- when I want to talk about a puzzle, I talk about sort of the classic where train A is here and train B is here, and there's a track between them. This train travels at 75 miles an hour, and this one travels at 60 miles an hour. Then the question is, they're 100 miles apart. Where do they meet and what time is it? Well, that's a classic sort of puzzle, and I was always fascinated by those.

And there's this book by Martin Gardner of the mathematical puzzles. I have that book at home. I think if I would have had that as a kid-- and they're difficult. Some of those are difficult questions, but I know I would have been entranced by looking through that book as a kid.

Chapter 2 – College at Iowa State University

KURT M. ANSTREICHER: So moving on to college, where did you go to college and what did you study?

TIMOTHY J. LOWE: OK. I went to Iowa State University in Ames. So that's-- for those who really know that-- and there may not be many that know the geography of Iowa, but I do. And you do now, and you guys do-- about 35 miles west of Marshalltown. I primarily went there-- I guess a primary reason that I went-- first of all, I wanted to be in engineering. I just thought given my interests, I liked mechanical things, I liked mathematics, I liked-- I thought I liked, at least-- sort of the economic part of things, which you certainly get in industrial engineering.

My brother went there, for one thing, so it's one of those-- my older brother. So it's one of those things, well, OK, he wanted to be an engineer. He went to Iowa State, 35 miles away. Why don't I do the same thing? So I went there with that in mind.

Also I actually had a varsity basketball scholarship there because in high school we had won the state basketball tournament the previous year, and I was fortunate enough to have gotten the basketball scholarship, which paid my way through college, which was nice. That was the only place the only place I ever even had a shot at a scholarship, so those are the reasons. I'm glad I went there. I mean, it set me off on a lot of things that I've done since then.

Chapter 3 – Getting a PhD at Northwestern University

KURT M. ANSTREICHER: And then where did you go to graduate school?

TIMOTHY J. LOWE: Oh, I went to graduate school at Northwestern. And I should say probably-- should back up just a little bit on why I went to Northwestern. Well, I got interested in operations research at Iowa State. And like I said, I hadn't heard anything about it in high school. But in college-- well, first of all, the industrial engineering department at Iowa State was very traditional. Very traditional IE program. Very little OR was going on then. Of course, OR was pretty new back then, too, I think.

But I had taken a course that was a sort of a survey of operations research, like just sort of the fundamentals of operations research. And I remember we solved a linear programming problem, a graphical, two-dimensional problem, using contour lines. And that's great. Gee, we can do that. But what do we do if we've got 16 variables? How can how can we do that?

So I talked to the instructor, who was an industrial engineering faculty member, and he said, well, you're going to have to go across the street. So I went over to the Ag Econ department and took a course on linear programming. And I remember sitting in that class, and it was a classroom where they had blackboards all the way around the room. Start here, and it goes all the

way around, blackboard after blackboard. And start the class, he'd have a linear programming problem. And then every time there was a pivot in linear programming, you'd have to rewrite the matrix, so pivot, pivot, pivot, pivot. And by the time-- after 45 minutes, you've got this notebook full of matrices.

And I thought, well, that's clever. But I don't have enough paper to solve real problems this way. So there must be a better way to do it. But to me it was fascinating. It was very fascinating to-- that's the first time I'd seen anybody-- I'd heard about the simplex method, but I've never seen anybody actually use it until I went to that Ag Econ course. But believe it or not, that got me excited about it. And eventually, I ended up at Northwestern because of that.

KURT M. ANSTREICHER: That's a great story. I like the one pivot per blackboard.

TIMOTHY J. LOWE: It'd drive you crazy.

KURT M. ANSTREICHER: So could you tell us ahead about some of the faculty that you met at Northwestern?

TIMOTHY J. LOWE: Well, first of all, I worked with Arthur Hurter, who was actually the chairman of the department. I chose him as my advisor because he was a mathematical economist. And I really-- I think what I wanted to do when I went there was I wanted to somehow tie economic concepts more closely with what was going on in operations research. And that was that was good that was a good thing for me, in terms of how it eventually turned out in terms of what I did.

Good technical faculty there. I think that the faculty we had at Northwestern at that time were terrific. There was Erhan Cinlar, in stochastic processes, who eventually moved on to-- I think he's at Princeton now. Bill Pierskalla was on the faculty, Elmore Peterson in mathematical programming, Robert Rosenthal who was in game theory at that time. So it was just a great experience. They were really really, really good.

I think one of the nice things for me in terms of exposure to these people, besides the faculty that were there in the program, I was very fortunate. I was asked to be the student host for a seminar series. So we would have a lot of people coming in to give seminars, well-known people in operations research. And you have to have a student gopher, and that was basically me for two years. And I didn't mind because it was a great opportunity to meet some of these people over time and get to know them, and maybe they'd remember me a little bit later on. And that actually turned out to be the case because having made those initial contacts, well, first of all, just good exposure, period, to be or be around them as much as possible. So that was to me that was a real plus of my graduate days.

KURT M. ANSTREICHER: So you mentioned that Art Hurter was your advisor. What was your thesis on?

TIMOTHY J. LOWE: My thesis was-- the title my thesis was called The Market Area Problem. And again, that sort of ties together sort of the OR stuff and economics and regional economics,

actually, because it was it was a problem involving manufacturing facilities where the transportation costs to move material from the site where they're being manufactured up to a customer base. There were production cost functions, and the idea is you've got this massive problem-- and messy problem, as well as massive-- where you're dealing with locating facilities and figure out which customers are served by which people. But it was it was a valuable experience for me because it was sort of my first look at location problems, which I eventually started doing more work in as I moved through my career.

KURT M. ANSTREICHER: So how did you come to pick that problem?

TIMOTHY J. LOWE: Good question. When your advisor says, this is a good one to work on, that's not a bad idea to do that. One other thing I think, Kurt-- I'm sure you appreciate this, too, or maybe you remember your graduate days. But you're sort of stumbling around trying to figure out, well, what can I do for a topic? It's got to be good or they're not going to let me out of here, and I have to work with somebody I get along with. And some of these people you've had a class from, and some you haven't. So how do you-- it's a tough problem for graduate students. And I guess I solved it by asking him one day, well, what's interesting here? And he pointed this one out, and I sort of took off there.

So that's a topic that he was interested.in. In fact, he'd written a book. He'd actually co-authored a book using some of the materials that we were dealing with in that dissertation. But also on the Northwestern campus, Leon Moses, who had was a longtime Northwestern faculty member, he was in economics and at the transportation system-- a transportation center. They had a center for research at Northwestern. I think they still do, and I think it might be in the civil engineering department, in fact.

But Leon Moses was involved with that and with that center, as well as being in economics. And then I remember taking a course from him, too. So he was on my committee. Part of the reason I guess I picked that topic is because of the course that I took from him.

KURT M. ANSTREICHER: So did your thesis work have much influence on your subsequent research in OR?

TIMOTHY J. LOWE: A lot. A lot, because my early career, I did a lot of work in location theory. And in fact, it had a lot to do with where I took my first job. Dick Francis is somebody that I've co-authored-- he'd been a co-author on a lot of my early work, in fact, on my work until a few years ago, when Dick retired. So Dick was at the University of Florida, and that was sort of what attracted me to go to the University of Florida. That was actually my first teaching job.

Chapter 4 – Early Career Mentors

KURT M. ANSTREICHER: So you mentioned your advisor, Art Hurter, and of course, Dick Francis. Who are some other people that were early mentors in your career?

TIMOTHY J. LOWE: Well, besides the, I guess, mentors in my career, I would have to say some of these folks that were at Northwestern. But also I think that the people at the University of

Florida, because that's where you're getting started. And they talk to you about here's what you need to do. You've got to work hard, you've got to do this, you've got to do that. If you want to advance in this business, you have to do this.

So Mike Thomas-- Mike was the department chair there, and he was a Hopkins PhD. And I think his-- who was his advisor? I can't remember. Anyway, well known, I guess. And he was well-known. But Mike was the chairman.

Don Ratliff was there. Don eventually moved to Georgia Tech, and he is still, I think, associated with Georgia Tech. Donald Hearn was a mathematical programmer. By the way, all these, with the exception of Thomas, these are people that I've actually co-authored at least one paper with. Also Tom Hodgson was there. Tom does work in more production, production work, scheduling and these kinds of things. I have not co-authored with him. I was trying to think-- no, I'm not. But he's a good guy.

Anyway, I would call them my mentors because you walk in the door, you don't know anything. You don't know what the game is. You've been told back by your advisor, but now you're on your own. And just to see how they do their work, how-- they look like they're working, and they were working. People were in their offices working, and say, well, gee, maybe that's what you have to do. Spending time with them, going to seminars with them, and listening to their questions. Those are the sorts of things that I think really are important for a young person to get started in this business

Chapter 5 – Academic Positions at the University of Florida, Purdue, Penn State and the University of Iowa

KURT M. ANSTREICHER: So you mentioned your first academic position was in Florida. Let's talk a bit about your employment history. So can you talk about the different places where you worked and the work that you did?

TIMOTHY J. LOWE: Yes. Be glad to. I've been using the moving van several times here. University of Florida, as I mentioned, we were there for five years. This was the engineering department, so PhD in engineering, but operations research focus. Went to an industrial engineering department, University of Florida, which had some traditional IE, but there was a lot of what I would call OR work going on there as well.

After five years, had the opportunity to move to Purdue University . I think I mentioned that even as a grad student, I was really interested in more not just mathematical programming, but sort of connecting it with economics and these sorts of things. And going to a business school, that seemed to be what I should be doing, sort of short term, at least. So fortunate to get an appointment in the business school at Purdue.

And that business school, by the way, at the time, at least, and I think it's still true, was about as quantitative as you could ask for because their graduate program-- at that time, they were giving a-- it's called a Master of Science in Industrial Administration, MSIA. And when they started that

master's program, that was primarily for Purdue engineers. And there are a lot of Purdue engineers, by the way. That's one of the biggest number of alumni in engineering in the country.

The idea was to have the engineers come back, get a business degree in-- I think it was a 15-month degree. So the emphasis was more than technical, but these engineers weren't afraid of numbers written on the board. So it was a pretty technical business school. It seemed like that would be a good transition for me, coming out of engineering, to move into that kind of a business school.

But I also had a courtesy appointment in the IE department because IE noticed that I'd come from engineering and I knew some people over there, and they wanted to make a connection between the two departments. So that was that was a good match for me. So there I spent, what, 11 years, I guess, it at the Krannert school.

Some of the people that were there-- Gordon Wright was there. Actually, Gordie Wright was on the faculty at Northwestern. In fact, he was recruiting grad students to Northwestern. He called me and convinced me to go to Northwestern, and I show up and he's gone. He was then at Krannert. So I knew him because of the conversations I'd had with him, but that's how people move around in this business.

Other people that I worked with-- Bob Plant, which I will talk more about later on, Herb Moskowitz was there. Lee Schwartz was in the operations management area. Richard Wong-- Rich was a student of Tom Magnanti. That was his advisor, and worked some with Rich. And again, many of those people I've done some co-authored work with. That was a good stay for us, 11 years there. Our kids essentially grew up in West Lafayette, and there's still strong connections with people there.

Then, let's see, went to the University of Iowa, and two years before my good friend and colleague Kurt came to the University of Iowa. And we've both been there getting close to 30 years now. And the people there, of course-- Kurt is the first person I should mention people to, in terms of the quality of the faculty we have there. Ken Kortanek was on our faculty when I came here. Ken has retired and still has contact with us. Yinyu Ye, who was here-- we overlapped, I guess, maybe four or five years, and then he moved onto to Stanford. Who am I missing here?

KURT M. ANSTREICHER: Ann Campbell, Barry Thomas.

TIMOTHY J. LOWE: Oh, yes. Sorry. The important people. These are the young people. Ann Campbell, terrific person. She's very interested in operations management. She came out of Georgia Tech. Barry Thomas, who came out of the IE department at Michigan, who's now doing great work and he's also the current department chair. So things roll through time, and young people are now doing the kinds of things that we did when we were a little younger. We're still trying to work, of course.

KURT M. ANSTREICHER: So I think you were at Penn State for one year, too.

TIMOTHY J. LOWE: Oh, yeah, Penn State. I went one year to Penn State.

Chapter 6 – Non-Academic Positions at Exxon and the US Army

KURT M. ANSTREICHER: And then that's all your academic positions. But I think in the early years, you actually had some non-academic positions that had provided you some interesting experiences.

TIMOTHY J. LOWE: Yeah. Yeah. So there's the undergraduate, and then there's the graduate work at Northwestern. But in between, when I finished at Iowa State-- I first of all had gone through Army ROTC. So then you're obligated for a couple of years as an officer. This was during the Vietnam War time.

So I went to work for Exxon. I was a process engineer at a refinery in Louisiana. So eventually, I was called up to go to service for my two-year stint. I had the good fortune, as it turned out, to have taught FORTRAN IV programming at Iowa State as an undergrad. Now, this was sort of unusual. I guess I did have a good record, and I guess they recognized that, and they were short on faculty. So I ended up teaching FORTRAN IV programming, at least one quarter. We were on the quarter system back then. And that was fortunate for, for actually for a couple of reasons that I'll get into here in a second.

But the first thing that was important in terms of my career and what I did ultimately in the Army is I worked in data processing. Remember, this is during the Vietnam War. So they were short on people that knew anything about computers and computer programming. So they cut my orders for Washington, DC, and I worked for a department there that was called the Army Personnel Reporting System. So that outfit kept track of Army personnel wherever they were. There was a data record on every individual, and the data record contained all the information about basically their life in the service, things like where were they stationed last, how long were they at this assignment, and so forth.

So that was good. I didn't actually do any programming, although I learned machine language at that time, just sort of survival because we had people that were doing the coding there. Because what they're doing, the coding they were doing is they were rewriting the programs to be used in this Army Personnel Reporting System.

Now, computers back then, the big massive things with tape drives and all this, you've probably seen that -- you've probably seen the pictures of it. But it turns out that an incident happened that was sort of a career-- a mind changer for me. And I think this is an interesting story. I think about this a lot.

Chapter 7 – An Epiphany about Teaching

So I'm downtown Washington, DC, with a bunch of GIs, Army people, and we're in this ground floor of this building, an office building. Big glass window that looks out on the street. I think it was out on M Street or-- I think it was M Street. Anyway, it was one of the downtown Washington, DC, streets.

So we're working away. They're mounting the tapes up on the machine, I'm watching, trying to help a little bit. And I heard this tap on the window. There was a tap, somebody knocking on the window, just out on the sidewalk. And I looked over there, and there was this person. He points for the door. The door's down-- it's a big room we're in, but the door's down there to go out on the side. He points down there, I said, oh, OK.

So I open the door, and he came in and he stared at me. And he said, "you don't recognize me, do you?" And I thought, oh no. What did I do here? What could possibly have happened here? He said, "well, OK, I want you to remember one thing." He said, "I was at Iowa State as a freshman taking this engineering programming course. You were the instructor." I thought, oh, what's he going to say, because I still don't remember.

But he said, "I almost failed. I almost flunked out of school. But I came to see you several times. You encouraged me to stay in the program. You encouraged me to finish the course and stay until you graduate." And he said this. "Thanks to you, I stayed in school. And I thank you very much." He shook my hand and he walked out.

And it was sort of a epiphany for me, and I thought, you know what? That must be maybe what I should be doing with the rest of my life. I didn't immediately go back to graduate school from that incident. But I certainly-- I can still remember it today. I remember the incident today. So whatever that means, that was a signal for me to go do this.

Once I got out of the service, I went back to Exxon-- because remember, I started at Exxon, went to the service, went back to Exxon-- and worked about one more year. And I kept talking to my wife about, gee, I kind of liked the academic life. I liked learning. I didn't know what research was, at that point, never did any. But I relayed the incident to her several times about this person who said, maybe you've done a good job. You saved me. That's a little strong, but that's more or less what he was saying.

And she said, "OK, I don't want to hear any more about it. You either go right back now, or don't talk about it again." So pulled up roots, loaded the furniture in a U-Haul. We had one child at that time. Took off for Evanston from Louisiana-- Evanston, Illinois-- and that's when I started my graduate work.

Chapter 8 – How OR Has Changed

KURT M. ANSTREICHER: So you've had a long career at many institutions. Can you talk a little bit about how the role of OR has changed throughout your career?

TIMOTHY J. LOWE: Sure. I think what's happened is-- when you think about how OR started, think back long ago where the term operations research even was coined by someone, I think some of that started up in the war effort in World War II. They were concerned about things like tracking submarines or something. It was these search routines that all started there.

So that was originally driven by problems. That's where it first started, driven by problems. And then what sort of happened is it evolved over time. The subset of the operations research people

were more driven by, let's say, algorithms as opposed to-- even though the algorithms ultimately used in the problems, they got separated from the problems. Some people, not us, but some people look at it that way.

But I think what's happened now, it's sort of turned back again, and now things are problem driven again. You take some of the classical journals, like Management Science in particular, in the old days, you could publish an algorithm in Management Science. Now you have to have a problem. It has to be driven by a problem, so sort of this evolution.

The second thing, I think that the data processing community has had a tremendous influence now on operations research because now these things are being developed on the computer now that you can actually use these algorithms to solve big problems, instead of using a roomful of blackboards like I talked about with my first example of OR, of linear programming. So I think that's part of the evolution, is just back to emphasis again-- not emphasis, but sort of a requirement to tie it in to where it where it's really needed. That's my personal viewpoint, but that's what you asked for.

Chapter 9 – Convex Location Problems on Tree Networks

KURT M. ANSTREICHER: So you have a long publication record. What I'd like to do next is talk about a few of the papers that you wrote that have been the most influential. And for each of these, you could talk a little bit about the history and the collaborators. These are in chronological order. So the first one is "Convex Location Problems On Tree Networks." That was in OR in 1976.

TIMOTHY J. LOWE: Right. OK, that paper-- well, first of all, let me just sort of say what was going on in location theory at that time. That was in the '70s. Remember, I started my job in '73, and that's in '76. I got very interested in-- as I said, I went to Florida primarily because it's a good place, but secondly, Dick Francis was there. So we started doing and observing and doing work on location on networks because you could do location in the plane and in three-dimensional space, but we got interested in location on networks.

And it turned out that on general networks, several of these sort of classical problems in location theory like the multi-facility where you're minimizing the sum of costs-- the other one is where you're minimizing the maximum cost-- are difficult to solve, very difficult to solve, on a general network. And part of the reason for that is you've got alternative routes to get from one point to another.

On the other hand, on a tree network there's one simple path between any two points. And by simple, I mean a non-simple path would be a go here, up, back again, and then keep going. That's a non-simple path. Simple path is you never backtrack anywhere. But there's only one. OK, that seems reasonable. That would say that, gee, that ought to make the problems easier, and it does, on many of these classical problems, to solve the location of where you put something relative to existing things.

But what we were interested in is, gee, can we tie that in to these general concepts that you oftentimes see in mathematical programming like convexity? Convex sets, sort of a classical feature of a set of points is a line connecting any two stays in the set. You take any two in there, and the line between them stays in the set.

Convex functions-- if you're minimizing, you'd like to have it go like this, the function, because then if you find a local minimum, an area where you move the left or the right you're going to go uphill -- the convex function: a local minimum is a global minimum. That seemed to make sense in terms of what's going on in these network location problems on trees.

So what we did is we just sort of derived these concepts of convex sets, convex functions, and all the associated features that go with those when the network is a tree. And published it-- I remember George Nemhauser was the editor, and he loved that paper. He said, hey, we've got to have this paper, so we published it there.

It's a paper that has had a lot of cites. Now it's-- I think everybody pretty much knew that these problems were a lot easier on tree networks, but there was never any way of sort of generalizing it. And I think that's what we were after. It was a generalization of that work.

Chapter 10 – A Traveling Salesman Problem in Engine Design

KURT M. ANSTREICHER: So the next paper is one of my personal favorites-- "The Product Matrix Traveling Salesman Problem-- An Application and Solution Heuristic." So this appeared in Operations Research in 1987.

TIMOTHY J. LOWE: OK, good story on this one. I'm at Purdue. That's my second stop on this train of places I've been. Bob Plant, who I mentioned earlier as one of the people there, Bob Plant is originally from Connecticut. He'd been on the faculty and we got to know each other because he was interested in OR kind of stuff.

One day he started talking about this problem. The problem was when you rebuild a jet engine, like a Pratt and Whitney-- Pratt and Whitney is one of the manufacturers that makes these big jet engines that go on commercial airliners. Excuse me. The engines have to be torn down after a certain number of flight time, not years, but months or hours. They are torn down and then they have to rebuild the engine.

Well, one of the features in the engine is, first of all, is a turbine. Hot gases flow through and they drive a turbine, and the turbine then drives the compressor, which creates more compressed air combined with fuel that blows out the back end, and that's how you get your power. So in that stage of the engine-- actually, there are multiple stages where this happens-- the hot gases go through. Think of concentric rings-- small ring, big ring, and the area between the rings, that's where the gases flow through. And then they impinge on the rotor, like a propeller. They impinge on that, which drives the turbine.

Well, to distribute the gases in a uniform way around this-- I guess it'd be called the annulus between the two, these two rings, this area between, what you -- and what you want to have is

uniform flow. Anywhere you look on that 360 degrees, you want to have uniform flow of these hot gases going through because otherwise you'll get things like you get bearing wear because you've got a big shot here and not much here, and so you get wobbling and all this other stuff.

So the idea is to somehow figure out how to uniformly distribute the hot gases going through. Well, to help distribute the hot gases, they put in what are called guide vanes, which are just-- looks like this, but it's a piece of metal. It's bolted in, and it has a convex side. I guess I'll call this the concave side and the convex side. So they're adjacent like this, but they're featured around this ring.

So what do we mean by uniform flow? And how does the flow change? How does that area between them change? Well, if you put a new vane in, it doesn't have the same characteristics of what you took out. Secondly, some of these vanes can be resurfaced. Even though there may be scorched a little bit because of the hot gases, they could be resurfaced. But when they're resurfaced, also their configuration changes. So you're stuck with this issue about uniform flow.

Well Bob's-- going back to Bob Plant. Bob Plant, my colleague -- his father worked for a company that I think it's The Starrett company in Massachusetts-- somewhere, Massachusetts or somewhere in the east coast. You're from the east coast. You probably know what I'm talking about.

KURT M. ANSTREICHER: Yeah.

TIMOTHY J. LOWE: OK. And his father had developed this instrument to-- in fact, I think he actually patented it-- where what you can do is you could put a single vane in this instrument, and it takes a measurement on this side and a measurement on this side. So you've got to think of it as this is A and this is B, A side and B side. Then if you have that measurement on all of the veins as they go around the circumference, the area between them is the A of this side plus the B of this. So you've got A plus B-- A plus B as the areas around. But there's a different A and a different B for everything in between.

So that helps you, right? I mean, now we're starting to get some structure because we've got this instrument that we didn't have before. So then we thought, well, what does that mean in terms of uniformity? Well, we thought, OK, why don't we look at the variance? Why don't we look at the variance as measured, given any configuration, the variance-- there's some average value, and then the variance would be the deviation from that average.

So variance says you square things, right? So we end up squaring A plus B, and what drops out are some things that'll be constant independent of any build. And then A times B is what's left. That's what's unique about putting this thing here or this thing here.

So we've taken this seemingly crazy problem, sort of a geographical problem, and we turned it into a problem of a traveling salesman-- basically, a traveling salesman problem-- around the circumference, But where the cost terms between adjacent, quote, "cities"-- and these cities, in this case, are adjacent vanes -- that cost term is A times B. A of this and B of this, A times B.

Well, that's a special kind of coefficient matrix that you end up with. It's called a product matrix because of the product of A and a product of B. Well, it turns out that you can then solve an assignment problem. And if you're lucky to get a tour with the assignment problem, then you're done. And the assignment problem is solved very easily because it's rank one matrix in decreasing order and the other in increasing order, and pair them up that way. You're lucky if you ever get a single tour. If you don't get a single tour, then you can show that a patching algorithm would work quite well on this, meaning if I patch these two circles together, I break this and I break this, and I link them together like that.

So anyway, the patching algorithm works very well for this problem, and we were able to establish upper and lower bounds on the quality of the build that we get, which was great. This was a product that was actually used, for a while at least. I remember we took-- the algorithm, I should say. It runs very fast. We actually took a trip to Pittsburgh to one of the airline rehab facilities where they actually break down the engines, and we watched them use this instrument.

That was a fun, fun project. And the reason it was a fun project is it was an interesting problem to begin with. It had, I think, of sort of a clever solution, and it was a real problem. I mean, what more can you ask for? Anyway, that was a fun project. And of course, it solved-- well, we're talking about maybe at maximum 100 number of cities in the traveling salesman problem. The technology at that point is not what it is today. No one would use this today because the improvement in traveling salesman algorithms is such that this would be no problem to solve it exactly.

KURT M. ANSTREICHER: All right. Both of those papers involved networks in one form or another.

TIMOTHY J. LOWE: Yes.

Chapter 11 – A Location Problem in Tooling Design

KURT M. ANSTREICHER: The third paper is an operations paper, "Rationalizing Tool Selection and the Flexible Manufacturing System For Sheet Metal Products." That appeared in OR in 1990, and at least the topic doesn't seem to involve networks. So could you talk about that a little bit?

TIMOTHY J. LOWE: Yeah. So again, just sort of the back story a little bit on this one, Mark Daskin and Phil Jones were both at Northwestern at that time, and I was at Purdue at the time. I went to Northwestern to give a seminar. After the seminar, we were sort of talking about things they're working on.

They brought up this problem where a company, if it's producing sheet metal products-- might be the side of a transmission, and the transmission needs to have some holes in it because you got stuff going through-- probably most of the technology at that point was to create a single die that would stamp out exactly what you needed. Well, the problem with the die technology is when the design changes, you've got to go get a new die made, which basically will do everything in one hit like that. But if you change the product, the die isn't any good anymore. So the alternative

is to punch holes one at a time, and there you would use a magazine. A magazine would hold the punches, extract, punch, put it back, pick out a new one, punch, sort of in an automated fashion.

Well, the problem there is that you've got a lot of different holes that you need to have punched, and you've got a lot of different tools. The tool magazine has a capacity you've got to worry about. But the basic problem is each hole has a certain sort of nominal diameter, but then it has a plus and minus tolerance that the user is willing to live with. You say, well, I want the hole to be half an inch nominally, but I could take 2 thousandths this way or 2 thousandths this way as sort of a little bit of slop in there. We can live with that.

Tools, on the other hand, a punch will punch-- as it wears down, its diameter that it's going to punch is going to wear down, so also there's some manufacturing tolerances in creating these punches. So the big problem here is, will this tool punch this hole? Well, it has to be able to fit. It has to be able to fit in that hole plus the plus and minus tolerances as well.

Well, if you think about it, a hole is basically one dimension that describes a hole, and that's the diameter. I mean, it's round. You can't say the same thing with a rectangle, but you can with a circle. So the problem essentially reduces to think about a line where you have intervals on the line. Think about those as being the diameters of the holes that you want punched. The tools then will take up a line segment as well, if you think about punching through the line. Then the question is, do these intervals, the hole intervals, are they covered by the tool intervals? And that turns out to be a location problem, a special kind of location problem, where you're locating-- it's a covering problem. And here you're covering a line with another line, or a gap-- an interval. Cover an interval with another interval.

And after talking with these guys about this problem, and I thought about it for a while and started to write things down, I recognized, well, that's a classical location problem. You're locating coverage. It's a coverage problem. And it turns out it's a special kind of coverage problem called a totally balanced 0,1 matrix. It's a covering matrix. And again, those are quite easily-- relatively easily, solved.

So that's another example of there's a real problem-- at least I was told it was a real problem. These guys, they're the ones that have gone out and talked to the manufacturers. I had not done this, but then you've got an interesting algorithm to solve.

Chapter 12 – Managing a Seed Corn Supply Chain

KURT M. ANSTREICHER: The next paper definitely involves a real problem. This is a problem with a nice Iowa connection. The paper was "Managing the Seed Corn Supply Chain at Syngenta" that appeared in Interfaces in 2003.

TIMOTHY J. LOWE: OK. A little bit of background here-- both Kurt and I have taught in our executive MBA program. And there was a student in that executive MBA program who, at least in my class and I think your class too, he sort of sat down front and he was very interested. This is the guy that was a co-author on this paper, and he worked for Syngenta. Still does.

OK. So I'll make this as quick as I can here. Corn is a big deal in the Midwest, and in particular in Iowa. What we're dealing with here is the production of what's called seed corn. Seed corn-- that's the basically production of the seeds that are going to be sold to farmers. They will plant those seeds and create these big fields of corn that we see around the state.

OK. So what's the big deal about seed corn? What's important here? Well first of all, to produce seed corn, you need two varieties. You've got-- it's basically a cross between this parent and this parent in the field. And the way that happens is the time you plant-- it's called male and female corn. It gets a little racy here, but you've got male corn, you've got female corn. They're planted at the same time. They grow up. And at some point, they start to get these tassels at the top of the corn.

And one of the favorite things for kids in the Midwest, a way to make money, is to hire on with these seed companies where it's called detasseling. And what you do is you go out in the field, and you've got these rows of female corn. You take the tassels off so they don't self-pollinate. You leave the tassels on the male corn so it will then-- that stuff falls in on the female corn, on the ears of corn, and that creates the hybrid.

That's how it gets produced. Now, keep in mind that you're producing in Iowa in the summer-- let's say this last summer-- to meet a market next spring. So there's a very long lead time. It's not like you can just in time the production of seed. There's at least a 12-month process between when you plant your product or try to plant your product and produce your product, and then sell it out here. So you've got demand uncertainty, you've got yield uncertainty in what you grow in Iowa. By yield I mean you get a hailstorm, and that could wipe out your field you're trying to produce a seed corn.

So that's it that's enough of a problem, trying to figure out what the production target should be here to meet this because of the yield uncertainty and the demand uncertainty. Well, the seed companies have come up with sort of a neat hedging strategy. What they do is plant in the Midwest to try to produce a particular hybrid. And keep in mind, there are multiple hybrids. There are all kinds of-- their product line is huge. They'll plant in the Midwest to produce.

And then what they do is they have sort of a what if or in case strategy that they can then produce in what is our winter or late fall, they can produce in South America because, of course, our winter is South America's summer. And so what they're going to do is plant down there, produce down there, and take that result that's down there, and add it to whatever was made in the Midwest, and then they've got the hybrid grown.

So what you basically have is two opportunities. You've got the more expensive backup process in South America, and so what you want to do is figure out, well, what's the best strategy, realizing I've got uncertainty here, I've got uncertainty in South America, which is more expensive, and then I've got demand uncertainty. Well, so what we ended up doing and working with Mr. Kegler, because he could get some information for us, some data for us, what we ended up doing is developing this production optimization problem with two stages of-- actually, three stages of uncertainty.

It was a fun project because, actually, we could demonstrate that if they had used this, they would have lost some here and gained some there. But overall, it was a net positive for them, had they done that. So what I mean by had they done this, we had the results of what they did and the information that they had, and the outcome that they got. We took, basically, their input that they used when they made their decisions without the algorithm, put it into our algorithm, and then what we did was we compared it. And as usual, with any problem under uncertainty, you win some and you lose some. But the idea is to on average do better because they do this over a lot of different hybrids.

Anyway, that was a great project. It turned into a couple of publications for us. It was a finalist in the Edelman competition in early 2000, which was great because that was good for Syngenta. It was certainly good for our work here. That was with Phil Jones and Greg Kegler, and Rodney Traub, who used to be on our faculty here.

And most recently, we wrote a case about this, a case that can be used in the classroom. And we were recently awarded the winner of the case competition. So lots of good things came out of that project. And I think back through the things that I've done and the work that I've done, and a couple of things pop up as most important or most fun for me. And that was one of them. That was that was one of them.

Chapter 13 – The Impact of These Papers

KURT M. ANSTREICHER: So could you talk a little bit about the historical importance of your papers?

TIMOTHY J. LOWE: Well, how do we measure importance? I don't know. Here's what I here's what I think. I'm going to pick sort of two areas here. One is the work in location theory. As I mentioned, Dick Francis-- and as I said, I've done a lot of work with Dick over the years. He's been really good to work with. I think our work, that early work on-- and continued work, actually, on location theory has really helped a lot of young people that are sort of coming through their career.

One of the things that-- one of the frequently cited papers, for Dick and I at least, is we wrote a survey paper on location on networks that appeared -- it was a two-part, part 1, part 2 in -- Management Science. This would have been in the '70s, I guess, that's frequently cited because it sort of lays out what the problem areas are in this network location stuff. And then I think that convexity papers has helped a lot of people as well.

I think the second thing that I would cite here is, in terms of if I look at that influence stuff, would be the work in agribusiness. Mostly what I'm talking about here would be that corn problem. So I sort of made a decision several years ago. I thought, I live right in the middle of all of this stuff, the agribusiness. Why am I thinking about manufacturing, so much about manufacturing? Why don't I think about a problem area that's around me, and that's ag?

So what I did is I was a Senior Editor of Manufacturing and Service Operations Management Journal, which was one of the new journals that popped up several years ago. And I was asked,

would you like to do a special edition of the journal? I thought, sure. Why don't I do something that's going to get people excited about doing research in agribusiness? I mean, agribusiness, it's been around a long time, right? Planting things and harvesting things, it's been around a long time. But I think it's been pretty much neglected until a few years ago by operations research. I think everybody is running off and doing things with manufacturing, and here's an area that could really use some help.

So what I did is I co-edited this special issue, wrote-- sort of the first paper in there -- was a call for research. Basically, what it was, was look, we need to get our act together and get some work done in an agribusiness. And then, of course, I invited some people to contribute to this special issue. I think that that thing in terms of influence is-- there's been a lot of influence on that because now-- that never was the case before. But now in our national meetings, there are several sessions on agribusiness. There are a lot of people working on it. A lot of people cite that appeal, that call for research that's the first paper in that journal. So I would say those two things are the primary things that I feel have an influence.

Chapter 14 – Professional Roles at INFORMS

KURT M. ANSTREICHER: So over the years, you've had a lot of involvement with professional associations, in particular INFORMS. Could you please talk about some of the roles that you've held?

TIMOTHY J. LOWE: Yeah. I've been involved in some of the national meeting planning committees. When I was in Florida, it was in Miami. I think of both of them were in Miami that I helped with, which isn't a bad place to go for a meeting. I was a contributed papers chair or some task sort of at the top of the food chain for that conference.

Nicholson-- I was on the Nicholson prize committee. The committee to choose Fellows, the Fellow selection committee, I was on that. A couple of other things. I think one of the-- not that many, quite frankly, but I worked with the Visiting Lecturer program. I was chair of that for a while. That's the one where INFORMS basically will help to pay for the expenses of somebody that's on their panel. They will go out and give a seminar at a school. The idea there is to stir up interest in operations research in places that may not have emphasized it too much.

The one I'm really most proud of and I think spent a lot of time on it is the committee called the Expository Writing Committee. I felt that we should be rewarding people that are good writers, that are clear writers. If you publish a paper and it's got some really good results in it, but if people can't read it because you're a terrible writer, then it doesn't have much value except to those people who don't mind filling in some gaps because something wasn't said here that should have been said here. So I thought it was important to start encouraging people to be better writers because I think we're all better off. I think operations research is better off because there's still a lot of people who don't quite know what we do. But if we're better at explaining it to begin with, that can't hurt.

So I chaired that, I think, a couple of times, two different times. And I really pressed on the importance of that. And that's an award that still continues. It's named now the Saul Gass Award

because Saul was one of the early on awardees, and everybody felt he was good enough writer, we'll just name this after him.

Chapter 15 – The Pedagogy of Operations Research

KURT M. ANSTREICHER: So you have a very long teaching career. Do you have any observations or insights on the pedagogy of operations research?

TIMOTHY J. LOWE: Yes. I think back about how I used to teach a course-- of course, technology has changed a lot. I used to write a lot on the chalkboard. And then if I used an overhead projector, I'd hand write my transparencies. And my handwriting is not good, so that was really bad for the students. I think the technology has helped us a lot,

Also I think that people are using cases more, which I sort of turned the corner on that. I used to think that was unnecessary. I think when I first went to the business school at Krannert, and all these people were using cases, I was thinking, what? Why are they doing this? Why don't they just go to the board and start writing things down?

Well, after I started using cases for a while, I finally figured it out, hey, that's not a bad idea because it gets people interested in what you're doing. It plugs them in. So yeah, I think there's more of that now. I think that's helped us. I think the analytic stuff has helped us. Now we can say-- well, we don't disregard the term operations research. But if we say business analytics, that is more information for people because that's been in the newspaper. Operations research hasn't been much in the newspaper. So I think -- that's I think that's how I see evolving over time.

KURT M. ANSTREICHER: So we've talked about the cornerstones of teaching, research, and service. Are there any other interests you have you'd like to talk about outside the normal classroom activities?

TIMOTHY J. LOWE: Sure. Couple of things. First one is I teach short course with a colleague at the University of Pittsburgh on project management. It's a two-day short course for practicing project managers. This thing, I'll make it very quick. We got this started one time when were at a national meeting, my colleague from Pittsburgh and I. We were in grad school together, and we were talking and in time we said, we both like teaching in exec programs. It'd be fun if we could do something sort of outside of what we normally do in the university.

So we put together this short course on project management. And we now-- it's been a very popular program. We've taught that-- we counted them up the other day. It's a two-day course-- 110 times, something like that, that we've taught that course over 20 years. And it continues on. So that's fun. The market has turned down a little bit on our program, and we'll continue to do it.

We've done it in many places around the country, many different companies we've done it. Well, I shouldn't say many. That sounds like a whole list. Probably five or six different businesses that we've been to to teach that course, and then it goes well because these are practicing project managers. And we bring in software. Microsoft Project was one of them -- Microsoft company has built a project management software. We use that in the class and show them how it works.

Chapter 16 – Restoring Classic Cars

Other than that, this is something-- a hobby that Kurt and I both share, and that's working on rebuilding and fixing classical cars, sports cars. So in my lifetime, I've had an MGA, a 1957 MGA that I eventually gave to our son. I now have an Austin Healey, a 1962 Austin. These are British sports cars that I work on all the time, love to work on. And I also recently got an old Corvette that I like and I work on.

But you know what I like-- it's a good hobby because what I like about it is you're using this all day when you're sitting at your desk. When I go there, I mean, I have to think about things when I'm restoring them, but a lot of it is physical. So it makes a good break from what I normally do. And I love to go down to the garage and fix the car. Actually, sometimes I look forward to something breaking. Can you believe this?

KURT M. ANSTREICHER: Well, you don't have to wait too long with the British cars.

TIMOTHY J. LOWE: Good point. That's true. That's true.

Chapter 17 – Wrap-up Questions

KURT M. ANSTREICHER: So we're nearing the end of this interview, and I've just got a few wrap-up questions.

TIMOTHY J. LOWE: Sure.

KURT M. ANSTREICHER: How would you like to be remembered?

TIMOTHY J. LOWE: I'd like to be remembered as someone who has done careful work, good work, and careful work. Careful about what I publish-- I've had a few issues where things haven't-- not intentionally -- but a few situations where things have sort of slipped by me, and I regret that, publishing something that wasn't quite right. And I don't need to go into that, by the way, except to say that I try not to do that. So I like solid work, being careful about that.

And then also as someone who is a good mentor. I think that's what people like Kurt and I should be doing now. I'm emeritus. I've retired from my position here at Iowa, but I still am here. I still go to work here. A good mentor for young faculty and also for young new PhD students, working with young people, trying to bring them through the system, and trying to teach them what I think is the right way to do it.

KURT M. ANSTREICHER: So can you talk a bit about how the field of OR has developed throughout your career?

TIMOTHY J. LOWE: , Well I've sort of touched on that already, but I think that the development business is there's more influence now with computer science, which I think is good. I think we have to be careful and make sure that we keep our hands in all of this because-- I'm not saying that other areas shouldn't be making claims about things. But I think for our own

future, we've got to make sure that we're making people know that where a lot of their stuff is coming from, it's coming from the operations research community. So evolution-- chalkboards, handwritten transparencies to PowerPoint to computer demonstrations to getting students on computers.

KURT M. ANSTREICHER: So what do you think is the most valid criticism of OR? And how would you respond to that criticism?

TIMOTHY J. LOWE: I've also sort of answered that, too. I think writing. I think the communication stuff. I think that in the classroom, the courses we teach, we've got to motivate and not teach by a student looking at our back because we're writing on the board, which you don't do and I don't do. I think there are still some people that may do that. So in the classroom, communication, and certainly in our writing. That's what we've got to do, I think.

KURT M. ANSTREICHER: So last question.

TIMOTHY J. LOWE: Continue to do it, continue to do it.

KURT M. ANSTREICHER: If you had a smart student who was interested in OR, what would you tell them to specialize in? Or what would you suggest is a direction they might head into?

TIMOTHY J. LOWE: One of things, I guess-- I mean, I can always tell them, here's something that you should work on. But I'm not going to do that. What I would do is I would point out that just any area you look at, there are problems there. There are existing problems there, and there's some value of digging in yourself and going after it. And I think that's what I would do. I think I would say, look, every area, every area, everything that we look at, everything that we can think about, has issues. Nothing's perfect yet. So there's an opportunity in all these areas, and what you've got to do is you've got to pick something you're interested in, that you're going to live with for a while because that's important, because you start studying in an area, and then a year later you find you don't really want to do that. You've wasted some time.

KURT M. ANSTREICHER: All right. Tim, it's been a pleasure.

TIMOTHY J. LOWE: Well, thank you.

KURT M. ANSTREICHER: Thank you very much.

TIMOTHY J. LOWE: Thank you, Kurt. Really, I feel very honored to have done this. I appreciate the time you've spent, and thank you.