

CHARLES L. MAROHN JR.

CONFESSIONS
OF A
RECOVERING
ENGINEER

TRANSPORTATION

FOR A

STRONG
TOWN

WILEY

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This book is dedicated to the memory of Destiny Gonzalez and all whose lives have been cut short by America's transportation system, and to Sagrario Gonzalez, her husband, Luis, and all who have suffered great loss on our nation's roads and streets, and to Sandra Zemtsova, along with everyone who must live knowing that others did not.

May this book reduce your pain.

Introduction: Conversation with an Engineer

“Hello, I'm the project engineer. I heard you have a concern about the street improvement we have planned for your neighborhood.”

I was feeling nervous about going out to speak with her, though I had no reason to believe that this would go poorly. I extended a hand as she stepped out her door and into the front yard. We had a firm but friendly handshake, and she gave me a smile.

I was the project engineer, and this was my job. I needed to be able to speak with the public, smoothing over concerns, if I was going to advance in my chosen profession. I had been on many such visits with other, more senior engineers, watching and learning from how they handled sensitive interactions like this. Now it was my turn. I waited for her to speak next.

“Yes, I heard that you are planning to improve my street. What will this mean for my neighborhood?”

Perfect. I had anticipated this question, of course, and I knew exactly how to answer it. This is the reason why I was here. My confidence growing, I responded.

“We plan to correct deficiencies in the grade as well as deficiencies in the curvature of the existing alignment. We also plan to enhance the clear zone in order to bring the street up to an acceptable and safe standard.”

She gave me an odd look, like I was speaking a foreign language.

“So, you are going to make the street safer?”

“Yes, of course.”

“How are you going to make the street safer?”

Civil engineering is a four-year program, although most of my peers took five to earn their degree. The four-year pace is rigorous, while the coursework is deeply technical. Upon graduation, an engineer wishing to be licensed will take a grueling, eight-hour test called the *Fundamentals of Engineering Exam (FEE)*, after which they become an *Engineer in Training (EIT)*.

The path to licensure then requires the EIT to work for four years in an apprentice capacity under the direct supervision of a licensed engineer. This is a time to go beyond theory and become knowledgeable in the standards and practices of the profession. After four years of gaining wisdom through working, and only with the support of another licensed engineer, an EIT becomes eligible to take the licensing exam and become a *Professional Engineer (PE)*.

I attained my degree in four years. I passed the FEE on my first try. I had done my four years working as an EIT for some distinguished engineers, and I passed my licensing exam on my first attempt.

I stood in this yard, adjacent to a street I had been asked to design, as a licensed PE — the proud steward of wisdom that, in some respects, dated all the way back to the ancient Romans, Greeks, and beyond. This might be my first solo project, but I was confident because I knew what I was talking about.

“Well, first we are going to correct deficiencies in the grade and in the alignment.”

“What does that mean?”

Safety is the primary responsibility of any licensed engineer. There really isn't a close second. It's written into our codes of ethics. It's embedded into our design processes. Safety is the reason why the state requires a license to practice engineering. It's why the city hired my firm for this job. It's why I was standing there.

If there was one single thing motivating me on this project, it was the desire to make this street safer.

"It means the grade and alignment of the street do not meet the standard, and so we are going to fix that."

"What is the standard?"

My understanding of safety in this situation comes from accepted industry practice. Engineers have books of codes and standards that outline all aspects of safe design, from how wide to make a street to where to put the signs. I not only had access to these texts, I had been trained in how to interpret them properly.

I recognized that my role in this interaction was to simplify all of the complicated factors that go into designing a street — all of the institutional knowledge of my profession — into something that a layperson could understand.

"Basically, the street must be relatively flat and straight."

"So, you are going to make the street flat and straight?"

"Yes."

"How does that improve safety?"

My ability to stay friendly and professional here was important. The woman to whom I was speaking hadn't sat through the traffic engineering courses that I had taken — the ones that taught me the history of roadway design. She didn't know the horrible death rates of the early automobile

era — the time before engineers established modern best practices.

She didn't have the training and the background that I had, including access to all of the code books and standards that my profession had developed over decades. She hadn't done the continuing education, sat around the table with my fellow engineers hearing the tales about how bad decisions led to bad outcomes and sometimes even death. I forced a half smile and went on.

“It will allow cars to navigate more smoothly, which makes it safer.”

“I don't understand.”

In traffic engineering, randomness is the enemy of safety. The more variables that we can remove, the more the driver can predict what is going to happen and the safer things become. For the driver, a road that is straight is safer than one with a lot of curves. A road that is flat is safer than one with a lot of hills.

It was difficult for me to explain something so self-evident, so I tried to expand the conversation to an aspect of design that would hopefully be easier to grasp — someplace where we could develop a common understanding and build to more complicated concepts.

“Along with fixing deficiencies with the grade and the alignment, we will be widening the driving lanes.”

“What will that do?”

“It will improve safety.”

“How does widening the lanes improve safety?”

Okay, this was getting frustrating. It is a little too obvious that wide lanes are safer than narrow lanes. Anyone who has tried to drive down a narrow street, having been forced

to slow way down to avoid hitting things, knows that having more space gives the driver a higher safety margin. This was Road Design 101— the most basic of concepts. I was starting to think that this woman, despite her friendliness, just didn't want to get it.

“Along with fixing the deficiencies in the grade and the alignment, it will allow traffic to flow more smoothly.”

“What do you mean by allowing the traffic to flow more smoothly? How does that improve safety?”

“Cars will be able to move without worrying about hitting things, so it will be safer. That is why we are also expanding the clear zone.”

“What do you mean by expanding the clear zone?”

Having a *clear zone* on each side of the roadway is another one of these basic design concepts universally understood to improve safety. If a car goes careening off the road surface, all that kinetic energy needs to be dissipated. We don't want the car to be brought to an abrupt stop by hitting an obstacle; we want the process of slowing down to happen more gradually.

All traffic engineers have heard the story of a driver losing control, the car going off the road and hitting an obstacle that should never have been there, with tragedy being the predictable result. Establishing an area on each side of the road that is clear of obstacles increases the chance that people will walk away from such an incident. I was taught to insist on it. No compromises with safety.

"We will be removing obstacles from the clear zone to improve safety."

"What is the clear zone?"

"It is the area on each side of the street that we need to keep clear of obstacles in case cars go off the road."

"What kind of obstacles?"

"Mostly trees."

I steadied myself because I had been in this situation before and knew what was coming. We were standing in a yard full of trees, many of which were going to be cut down. I knew she wasn't going to like that. It seemed a selfish reaction to me.

Most people seem to want progress. They show up at public meetings and demand all of the conveniences that come with driving. They want it, that is, until it impacts them directly. *Then* progress must be stopped. Then they all turn into environmentalists. I'd seen it many times. She seemed to fit the profile, especially with her next question.

"So, you are going to remove the trees from the clear zone to improve safety?"

"Yes. Exactly."

"How big is the clear zone?"

I took a deep breath and looked down. "The clear zone is 25 feet on each side of the street."

"Twenty-five feet! That is my entire front yard!"

I wasn't going to compromise on safety. I had a code of ethics demanding that I put the welfare of the general public ahead of concerns like this. I had worked years to get my license, and I wasn't about to risk it by not following the design standard.

Plus, the firm that I worked for had professional liability insurance, which I knew was expensive. We live in a litigious society. There was no way that I was going to be bullied into doing something irresponsible — something that threatened my client or my firm, let alone the people who would drive along this road.

“I’m sorry, but the standard requires that for the road to be safe, all obstacles must be removed from the clear zone.”

“Do you understand that my children play in this clear zone?”

“I would not recommend that. It would not be safe.”

“But it is safe today. I thought you were doing this project to improve safety. How is the street safer if my children can't go outside?”

I was having a conversation with this woman at the request of the mayor. She was one of his constituents. I knew that my job was to listen to her and answer her questions, but it was also to demonstrate that the city had performed due diligence on the project. If she showed up at a future council meeting complaining about her kids not being able to go outside to play, she was less likely to be taken seriously if everyone knew that I had personally met with her, answered her questions, and seen her property firsthand. I'm the professional and, after being on site and meeting with her, I can confidently say that nothing unique is happening with her property, regardless of what she might suggest at a public hearing.

“Building the street to meet the standard will enhance safety by allowing cars to flow more smoothly.”

“More smoothly. The cars will just drive faster, will they not?”

By statute in my state, the city is not able to enforce any speed limit lower than 30 miles per hour. There are exceptions, but those require extensive studies and proof that there is some unique circumstance justifying the lower speed limit. We weren't going through that effort here. The city didn't have the budget for such a study and, even if they did, there were no special circumstances that would justify doing so.

Once the street was built, if there was reason to believe that 30 mph was the wrong speed, I could do a speed study and make that determination. Such a study would involve monitoring the speed that traffic was naturally flowing, which my experience suggested was unlikely to be less than 30 mph. She should be careful what she wishes because a speed study is more likely to result in a higher speed limit than a lower one.

"We will post a speed limit after we do a speed study and determine the safe speed for the street," I said with some added authority in my voice.

She replied with equal authority. "But cars drive slow now. Slow is the safe speed through my neighborhood where my children are playing in my yard. How does it improve safety to have a drag strip out my front door?"

"It will increase safety because traffic will flow more smoothly. That is the standard."

At this point, the two of us had cycled through all of the typical objections that people bring up to oppose such projects. We had started with a friendly line of inquiry and eventually proceeded all the way to unresolvable acrimony. I had done everything that had been asked of me, and I was thinking it was time to move on.

She was not ready to let things go, however, and I started to sense that this conversation would get very emotional

before we were done. Her next words reinforced my uneasiness.

“I am not aware of anyone being killed in an accident on this street, and I have lived here for thirty years. Are you aware of anyone being killed?”

“No, I'm not.” I tried not to roll my eyes or sound like the teenager I was just a few years earlier.

“I am not even aware of any accidents that have occurred on this street. Are you aware of any accidents?”

I repeated, “No, I'm not.”

“Then why do you say that the street is not safe today?”

One of the frequent justifications for making roadway improvements is a tragic incident, especially a death. While those cases often seem random, they form a powerful justification for doing an improvement project, especially where you can tap into available federal or state funding. Multiple incidences can even create a sense of urgency. Since there is a seemingly endless list of roads that need improvement, prioritizing by death rate or accident rate can almost seem natural.

That wasn't the case here. We were proactively making the improvements to this street to make it safer — to bring it up to an acceptable standard in a way that would ultimately save lives. We weren't waiting for the accident rate to rise; we were getting out in front of that. It gave me a feeling of satisfaction in my work.

“The street is not safe because it does not meet the standard.”

“So, today cars drive slowly and it is safe, but you want to flatten the street, straighten the street, widen the street, and remove all of the trees so that cars can drive fast? Only afterwards will you post a speed limit so that cars will slow down? And you say this is safer?”

It was a clever recitation, but while the woman with whom I was speaking was clearly sharp-witted, she lacked the background knowledge and understanding that allowed her to grasp the situation fully. I would try one last time to enlighten her.

“Yes, it will meet the standard. And please understand that there are high traffic projections for this street.”

“What do you mean by a high traffic projection?”

“We project that a lot of cars will use this street in the coming years.”

We've all been on roads that lacked capacity, where the traffic was at a standstill. From the perspective of the traffic engineer, this is an absolute failure. We even give it a grade of F.

Traffic engineers use a scale to measure “level of service” that runs from A, for “free flow condition” where all traffic is moving unhindered, to F, where the flow of traffic breaks down and travel times are unpredictable.

Cities spend a great deal of time and resources analyzing and projecting traffic patterns. For this project, our models suggested a large increase in traffic, something that would create congestion and reduce traffic flow to Level of Service D — or potentially worse. All of the improvements underway were a proactive attempt to avoid bottlenecks

and keep traffic flowing. We were being proactive with this project and I was proud of that.

“Why would a lot of cars drive down this street? It is a small, narrow street where you have to drive slow.”

Now we were getting somewhere. Now she was asking the right questions — the ones that explained exactly why this project was so important. And I could surely sympathize with her not understanding what was coming. She hadn't seen the models my colleagues and I had put together. She wasn't the expert working with this every day. I felt a renewed sense of optimism. We were making progress. I replied excitedly.

“That is why we have to improve the street — to meet the standard.”

She gave me a sideways glance. “Won't that just encourage more people to drive?”

“We have anticipated that, and we are adding two more lanes to handle the additional cars.”

That insight was not received in the way that I anticipated. There was an uncomfortable period of silence — the kind where the person expected to speak is too startled to do so. Her eyes widened and she stared at me, not blinking.

“You are adding two more lanes?”

“Yes.” I was nodding knowingly.

“For cars?”

“Yes. An additional two lanes will allow the street to meet the standard.”

I looked down at my feet. I wasn't sure how to react to this conversation. It was clear that the woman with whom I was speaking was upset, but certainly she didn't want traffic

congestion in front of her home. I bet she'd be the first one calling City Hall if she was stuck in traffic every day at Level of Service F.

I just needed to help her understand what was already so clear to me. Yes, she might have to give up some trees and a little bit of her front yard, but didn't she want things to be safe? Didn't she want the road to work for everyone? She spoke next.

"Let me see if I understand. You are projecting a high volume of traffic where there is none today and then building a street to handle this traffic. Aren't you just encouraging more people to drive?"

"No. We are anticipating a lot of growth and need to make this improvement to handle the growth."

While I'm an engineer, I'm really in the growth business. All of us who work for the city are in the growth business in one way or another. New growth is how we get the money we need to fix the streets, pay for police officers and fire fighters, keep the library open, and all of the other things that taxpayers say they want. Growth is how people get jobs. It's the unifying focus that we more or less all seem to agree on.

The more growth that we can generate, the better off things are for everyone. Yes, there are some people who are anti-growth. They sometimes come to council meetings with a sentimental attachment to some old building, a concern over an environmental issue, or maybe expressing their concern with economic dislocation. There are generally a few speaking out against each project, but they usually aren't taken very seriously. What are we supposed to do? Stop growing? That would be a disaster.

She asked, "Where is all of this growth happening?"

"New growth is being created in the tax subsidy zone."

"Where is the tax subsidy zone?"

"The tax subsidy zone is on the edge of town."

In a recent planning process with the city, my colleagues and I identified many sites where infrastructure could be extended. These are places primed for growth, where public spending can be a catalyst for quick private investment. All of the major developers and business leaders were at these meetings, and they were enthusiastic for that kind of public support. That makes sense because they know what it takes to create growth.

To their credit, the city leadership followed through. They took on a lot of debt to invest in additional capacity. They applied for economic development grants from the federal and state governments. They waived fees and other development charges, and they streamlined the approval processes. Even more proactively, they established some tax subsidy areas, a move that had paid off with an initial round of development proposals. It was all very exciting.

"What kind of new growth is going to occur in the tax subsidy zone?"

"On the edge of town, there is a proposal for a grocery store as well as a drive-through restaurant and a gas station."

"Okay. But I go to the neighborhood grocery store across the street, I eat at the restaurant up the block, and I don't drive much, so I don't need another gas station."

I had heard this kind of thing before, but what she referred to as a "grocery store" was just a small neighborhood grocery. You couldn't get much there, nothing like the big

box store that my family bought groceries from, not to mention all of the families I knew.

The same thing with the restaurant. I knew the family that owned it from way back. They didn't really invest in their own place and, economically, they were being left behind. It was obvious. The whole neighborhood had been officially listed as blighted. It had seen better days, for sure.

Even so, if we were to get growth going out on the edge and get a good, high-capacity street running through here, there was a chance that someone would buy up these old buildings, tear them down, and build something new. That's about the only hope I saw for this neighborhood. The zoning codes wouldn't allow this old stuff to be rebuilt here again anyway. And for good reason.

“Yes, we know. That is why we have planned for a pedestrian overpass on this block.”

“What is a pedestrian overpass?”

“It is a bridge that will allow you to get from one side of the street to the other safely.”

“But I can walk across the street safely right now. My kids can walk across the street safely right now. Why will I need a pedestrian overpass?”

I felt like the answer was obvious here and that, once again, she was almost deliberately trying not to understand. She had just told me that she wanted to cross the street. With all of the additional cars speeding through here, how did she think that was going to happen?

“With four lanes for traffic, you will not be able to walk across the street without slowing down the cars. Slowing down the cars would not be safe.”

“But I am not going to be able to haul my baby stroller up a pedestrian overpass every time I want to cross the street to buy milk. How does this benefit me?”

I was out there working on a project being done for the greater good. All of the safety improvements, all of the new growth that would result, all of the jobs that were going to be created — including mine — were a benefit to the entire region.

Here was one person asking how this benefited them. Did she not see the larger picture? Did she not care? Did she not recognize how selfish she sounded? It was clear to me that I needed to end this conversation.

“You will benefit from the added tax base from the new growth.”

“But the new growth is in a tax subsidy district. How much will they contribute to the tax base?”

“Nothing today, but in 10 or 15 years, they will contribute a lot to the tax base.”

“Why would we make an investment that will not start to pay back for 10 or 15 years? By then, the grocery store will be turned into a dollar store and there will be a new tax subsidy zone.”

There are always people against tax subsidies. Generally, I would be one of them, but I had been in the meetings with investors and developers. I knew that none of this investment was going to happen without the tax subsidies. And if this city didn't have new investment, more places would start to look like this blighted neighborhood.

“If we do not provide the subsidies and invest in improving streets, the growth will not happen. Without growth, our city will die.”

“But if I can't walk across the street to the grocery store, it will go out of business. If I can't walk up the street to go to the restaurant, it will go out of business. Nobody is going to want to buy my house with a highway outside my front door. Do you care that my neighborhood is dying?”

It was precisely because her neighborhood was dying that I was out there. This project was the neighborhood's best hope for revival. If I could get more traffic flowing through here, more people from outside of the neighborhood passing by, this neighborhood would have a chance for some investment. Why couldn't she see that I am part of the solution?

“Yes. That is why we are investing in new growth. That is why we are improving the street.”

She looked past me, off into the distance, one of those long stares that people do when they are collecting their thoughts. I reminded myself that she had a lot to process here. My patiently exhausting her line of questioning was part of that process. I waited for her to speak.

“So how much will this street improvement cost?”

Now we were back on solid ground. I had prepared the cost estimate and knew this answer.

“The total project cost is nine million dollars.”

“Nine million dollars! Our city is broke. We can't afford to keep the streetlights on overnight. We have laid off our fire fighters and half our police force. Where are we getting nine million dollars?”

I understood the sticker shock. This was a large project, especially for this community, but now I had a chance to impress her. All of this new investment, all of these improvements, all of the new growth that would result, and all of the jobs and economic development was going to happen and most of it was being paid by others. As a taxpayer in this city, she was getting a tremendous gift.

“Seven million dollars is stimulus money coming from the state and federal governments. The other two million dollars will be assessed to the property owners that benefit from the project.”

“What does that mean, ‘assessed to the property owners that benefit from the project?’”

Cities are limited in the taxes and fees that they can charge property owners. Some of this limitation comes directly from equal treatment provisions in the U.S. Constitution itself. One exception to treating everyone equally is the assessment process. When assessing, a local government can charge a property owner whatever amount they want to so long as the property value they own increases by that amount.

If the project increases a property's value by, say, \$10,000, the city could charge the property owner up to \$10,000 for doing that project. The engineering firm where I was employed did this kind of work all the time. In fact, this neighborhood had been so neglected, the public infrastructure in such a state of disrepair, that just having new pavement was likely to improve this woman's property value.

Nonetheless, I dialed back my enthusiasm, reverting to the classic-speak I had heard other engineers use in public hearings on assessments.

"It means that the property owners who benefit will pay a share of the cost."

"Who is it that benefits from the project?"

"Everyone who is on the street."

The vacant stare evaporated. She looked me straight in the eyes, a combination of frustration and confusion apparent on her face.

"Wait, are you saying that I benefit from this project and will pay an assessment?"

I again looked down at my shoes. I tapped the ground with my foot, a reflexive behavior.

"Yes. You are one of the benefiting property owners who will be assessed for the project."

"You must be kidding me. I have a nice quiet neighborhood street today. My kids play in the yard and it is safe. I can walk across the street to the grocery store, or up the street to the restaurant, and it is safe. To make it safer, you are going to flatten, widen, and straighten the street and add two more lanes of fast-moving cars. This is done because of traffic projections — because we want new growth in the tax subsidy area on the edge of town. And while my neighborhood crumbles and my home drops in value, you are going to assess me, too."

I felt bad for her. She truly didn't get it.

"I'm sorry. But the traffic projections require a four-lane street for safety reasons. We must follow the standard."

This conversation is a composite of many conversations I participated in during my years of working as a civil engineer and urban planner for cities across Minnesota. The thoughts and words I attribute to myself in this

dialogue are all ones I've believed or expressed at one point or another during my career. In 2010, I shared these impressions in a YouTube video I titled, "Conversation with an Engineer." The eight-minute exchange between two computer animations is now used in university courses and other training sessions. It has been watched over 340,000 times and can now be viewed at www.confessions.engineer.

For many years, I believed that my education, training, and license gave me superior insight into how cities work. I believed that I was uniquely positioned to know what was best for society — at least when it came to transportation.

I believed that the optimal approach to city-building was reflected in the codes and standards that had been developed by others in my profession and that adhering to them was the only responsible approach an ethical person could take.

I believed that the straighter, flatter, and wider we could make a street, the safer it would become, and that requiring clear zones free of obstacles on each side was a critical component of public safety.

I believed that the speed people drove reflected their own level of responsibility or recklessness, that my designs had no influence on traffic speed, and that the only real way to address speeding was through police enforcement and public awareness campaigns.

I believed that automobile crashes, and the frequent incapacitations and deaths that accompanied them, were random events mostly caused by driver error, that the best thing I could do to reduce human suffering was to strive to continually improve our transportation systems to higher and higher standards.

I believed that I could use models and simulations to predict future traffic flows and that I had an innate sense