

# SCIENCE IN THE NEIGHBORHOOD

HOW STEM PROFESSIONALS KEEP  
SACRAMENTO CLEAN, DRY, AND MOVING

(PLUS SECRETS OF  
HOW EVERYDAY THINGS WORK!)

DR. AMY ROGERS



SCIENCE**T**HRIILLERS MEDIA



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Versions of these articles first appeared in *Inside Arden*, 2014-2018. All images obtained with rights from Shutterstock.

Publisher@ScienceThrillersMedia.com  
www.ScienceThrillersMedia.com

Publisher's Cataloging-In-Publication Data  
(Prepared by The Donohue Group, Inc.)

Names: Rogers, Amy, 1969-

Title: Science in the neighborhood : how STEM professionals keep Sacramento clean, dry, and moving : (plus secrets of how everyday things work!) / Dr. Amy Rogers.

Description: Sacramento, CA : ScienceThrillers Media, [2018] | "Versions of these articles first appeared in *Inside Arden*, 2014-2018." | Includes index.

Identifiers: ISBN 9781940419213 (paperback) | ISBN 9781940419220 (ebook)

Subjects: LCSH: Science--California--Sacramento--Popular works. | Engineering--California--Sacramento--Popular works. | Public utilities--California--Sacramento--Popular works. | Urban transportation--California--Sacramento--Popular works. | Ecology--California--Sacramento--Popular works. | BISAC: SCIENCE / Essays. | NATURE / Regional. | TECHNOLOGY & ENGINEERING / Social Aspects. | REFERENCE / Questions & Answers.

Classification: LCC Q162 .R64 2018 (print) | LCC Q162 (ebook) | DDC 509.79454--dc23

Library of Congress Control Number: 2018902552

TO JAN AND DUFFY, WHO LED ME *INSIDE*



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# Foreword

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Science is in your neighborhood.

Many people think of “science” as memorizing a bunch of facts, things like the periodic table or the stages of mitosis. While the efforts of scientists in the past have indeed given us many facts that must be learned (lest we be forced to repeat all their experiments!), science is much more than facts. It’s an approach to learning based on questions and open-mindedness to the answers. It’s a way of explaining and controlling the world around us. Once you start to look, you’ll see that science—and her practical sister, engineering—are everywhere.

As a scientist, an educator, and a writer, I have a habit of seeing science in all things—in my home, my community, my region. But I have blind spots. Some everyday things I take for granted and I don’t notice how they depend on good science and engineering. I’m sure you have the same problem. And it is a problem. Just because it’s simple to turn on a tap, flush a toilet, or pump gasoline into your car, doesn’t mean that the systems behind these conveniences are simple too. If we don’t appreciate how complex it is to run a utility, then we will resent that it costs us money. If we don’t understand where our waste goes, then we have no reason to be careful about what we throw away.

To answer “how does that work?” questions for myself and for the community, several years ago I started writing a “Science in the Neighborhood” column for the hyperlocal newspapers Inside Arden, Inside East Sacramento, and Inside

Land Park. It's been an extraordinary opportunity to meet local science experts and engineers. I've toured restricted facilities like the control center for our high-voltage power grid, and our regional blood bank. I've interviewed National Weather Service meteorologists, and the executive director of the Sacramento Area Flood Control Agency.

Over and over, I've learned one very important lesson: Things are more complicated than you think.

From my very first article about the engineering behind traffic signals at local intersections, I've been impressed by the sophistication required to make things work. Science, technology, engineering, and math professionals, many of them employees of our local governments or supra-government districts, apply their knowledge and skills behind the scenes. Without them, we'd be uncomfortable, sick, and isolated in the dark—or worse.

By collecting my columns into book form, I want to celebrate these hidden science heroes, and possibly inspire a young person to consider a STEM career. I'll also introduce you to citizen science projects you can join; unique local ecology you can visit; and places you can hang out with science-minded people. I'll explain ways to save someone else's life and how to protect your own while driving, fishing, or exercising. But most of all, with this book I want you to see, as I do, the importance of science in our homes and neighborhoods.

Note to *Inside* readers: I've updated and expanded many of these topics to include a greater depth of information than I originally had room for.

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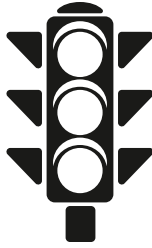


**PART ONE**



**TRANSPORTATION**





## Red Light, Green Light: For Traffic Engineers, Timing is Everything

Like every city in California, we have congestion problems on our roads. To get the best traffic flow possible on local streets, virtually every intersection with a traffic light is monitored and controlled. Not by random chance do you approach an empty intersection and the light turns green for you. Now I know why I never have to slam on the brakes for a yellow light: the engineers have the timing figured out.

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**U**nder cover of pre-dawn darkness, your platoon moves forward. All you want is to get through. Then it happens—you're in the Dilemma Zone, and your presence has been detected. The metal container shielding your body triggers eddy currents in a hidden wire, and now the ITS is taking control.

A scene from a military sci-fi video game?

No. Just the morning commute in Sacramento.

Fighting traffic feels like you against the world, but you're *not* alone. Engineers for the City and County of Sacramento Departments of Transportation are using advanced detection and communication systems, as well as old-fashioned mathematics, to help each automobile, bicycle, and pedestrian win the battle against congestion.

We all know the problem. Too many vehicles compete for space on Sacramento streets. In most cases, adding more lanes isn't feasible. So traffic engineers operate Intelligent Transportation Systems to make the most of the roads we have.

Traffic signals at intersections are the key to smooth traffic flow. Coordinated traffic signals allow a group of vehicles (called a *platoon*) to roll through one intersection after another, hitting green lights as often as possible.

How? In the simplest case—a one-way street, such as 16<sup>th</sup> Avenue downtown—the lights are programmed with a timing plan that calculates, based on distance and speed, how long it should take a platoon to travel from one intersection to the next. Other major commuter corridors are more complex, with two-way traffic plus many cross streets. Left and right turns, pedestrians, and cyclists all compete for time and space in the intersections. Giving a few seconds to one user takes from another, so trade-offs must be weighed across the entire system to synchronize progression. Light rail versus vehicles, main corridors versus side streets, and regional versus local concerns all must be considered. For example, to prioritize getting cars off highway 50 can lead to big jams at intersections on local streets such as Watt Avenue.

County Transportation Engineer Doug Maas has been balancing the needs of these different travelers for

over 25 years. According to Maas, the solution to optimal traffic flow is to combine timing plans with intelligent sensors and a human touch. For example, during the morning and afternoon rush periods, traffic signals are told to favor cars moving in the dominant direction. During the holiday season, signals on Arden Way “know” to accommodate more vehicles visiting Arden Fair Mall.

But minute to minute, the number and kind of users at an intersection is unpredictable. That’s where detectors come in.

Smart intersections sense big metal objects like cars and smaller ones like bicycles. Cameras, radar, and microwave detectors may be located over the street, on the mast arm that also holds the signal “head” (the red, yellow, green light). Embedded in the pavement are magnetometers and the most common kind of detector, inductive loops. (You can often see big looping lines in the pavement where these are buried.) These are loops of wire that constantly carry an electric current. When a metal object passes over the buried wire loop, the object’s magnetic field disrupts the current.

When a detector “sees” a vehicle, it communicates with the intersection’s brain, which is housed in a signal controller cabinet standing near one corner. The controller takes appropriate action. Usually this means giving the vehicle a green light. At an *actuated* intersection like this, green lights are never wasted on an empty lane, and when a car approaches, it quickly gets permission to pass.

Detectors relay their information via fiber optic or copper cables to nearby intersections to keep the whole corridor running smoothly. Data is also carried to the Traffic Operations Center.

At the county's Traffic Operations Center near Bradshaw and Kiefer, a bank of computers faces an entire wall of bright, high-resolution monitors. The screens are filled with live video of traffic at any of hundreds of connected intersections. Here, Maas and his team of engineers are traffic gods. From this remote location they can manually operate any signal lights on the network, and watch the effects on traffic in real time. This is critical during the morning and evening weekday commutes, when engineers are on duty to iron out wrinkles in the traffic flow. With a little ingenuity—adding a few seconds of green light here or red light there—Maas can usually clear unexpected back ups in two or three signal cycles.

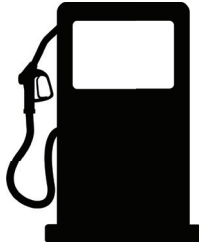
Every timing decision demands a trade-off. As Maas says, traffic planners are “fighting for seconds at over-capacity intersections.” If the system gives extra time to left turn traffic, other users—say, pedestrians—lose time to keep the whole corridor in sync.

But not all users are equal. When emergency vehicles are speeding to the rescue, they *need* green lights. Thus Sacramento Metropolitan Fire engines and ambulances are equipped with infrared strobe light emitters that trigger a “high priority pre-emption” of the signal timing at an intersection. As an emergency vehicle approaches, the signal controller changes the lights to give the responders a clear path. (Contrary to the urban myth, you can't fool the detector by flashing your headlights.)

I asked Maas about the notorious red light cameras at some intersections. He insists the traffic engineers set parameters for each signal to maximize safety and capacity. They don't make artificially short yellow lights in order to trap motorists and raise revenue for the Sacramento

County Sheriff's Department, which enforces the red light violations.

While no signal technology can eliminate the evening jams at Watt and Fair Oaks, watchful engineers shepherd the traffic flow as efficiently as possible. They confirm their data, too, with what Maas called "windshield factor"—driving routes themselves in real life and measuring total drive time and number of stops. Maas's department consistently beats national averages on the National Traffic Signal Report Card. The next time a green light stays lit just long enough for you to get through, you can bet it wasn't random luck. The ITS is on your side.



## Summer blend is not a coffee: Seasonal gasoline

The refining of gasoline is possibly the most consequential science/engineering business that nobody understands. Sacramento has only a tiny local petroleum industry, and no refineries, so I haven't written in depth about the process. But here is a glimpse of some of the complexity behind the pump.

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**I**n late spring or early summer, the price of gasoline typically rises. Part of the reason is supply and demand: Americans consume more gas for travel in warm weather. Another reason is regulatory, based on science: summer blend gasoline costs more.

What is summer blend gas, and why do we use it?

First, some background. Gasoline is not a single pure thing like water. It's a blend of different hydrocarbons