Responsible Citizenship in a Technological Democracy

Note 11: Control and Feedback

The previous Notes in this series have discussed ideas that a responsible citizen ought to know to analyze public policy issues. This one is a little different. It's an idea out of engineering that, IMHO, ought to be part of more policy formulation, but generally isn't. It's a tool that could make policy more flexible and adaptable, and hence responsive to citizens needs and changing circumstances. I suspect it's an idea that most policy makers never heard of, and hence never considered as a tool of policy formation. As responsible citizens, you should have it as an arrow in your quiver.

Control

Many engineered systems will have a component called a "controller" – a component that controls the rest of the system. The simplest of these are called "open loop" controllers. I'll explain that name in a minute, but an example is the controllers for old fashioned stoplights.

Early stoplight systems were simply driven off of a timer. The lights would be green in one direction and red in the other for a fixed amount of time, then reversed for another fixed period of time. Generally the times were chosen by sending someone out and having them count the number of cars going in each direction and making the times proportional to the amount of traffic in the two directions. That way, the direction with greater traffic got a longer green light. But those times were the same day and night. I, for one, have sat at an otherwise completely empty intersection at 2:00am while one of those controllers counted off the time allocated to the other direction.

The timers that some people use to turn their lights on and off while they are on vacation, and hence make the house looked "lived in" is another example of an "open loop" controller. They turn the lights on at some specific time and off at another specific time.

Feedback

Almost all modern control systems are "closed loop" – by which we mean we take some measure of the environment being controlled and "feed it back" into the controller's decision process. The previous controllers were called "open loop" because they didn't get this "feed back" information.

One familiar example of a controller with feedback is a thermostat. It senses the temperature in your room and, in the winter if that temperature falls below some point, it turns the heat on. When the temperature exceeds some level, the thermostat turns the heat off. The net effect is to keep the temperature within a comfortable range.

Modern stoplight controllers have sensors embedded in the street so that, although still somewhat related to time, if there's no one that wants to make a left turn, the left turn part of the cycle

won't happen. At 2:00am, if there are no cars that want to go north-south, the green light for east-west traffic can just stay on.

The cruise control on your car is another familiar example of a controller with feedback. You select a speed that you want to go, and the cruise control keeps it there. At first blush it might seem that feedback isn't necessary – just lock the accelerator wherever it was when you engaged the cruise control. But in hilly terrain, for example, the car would tend to slow down as you go uphill and accelerate going downhill – and adding feedback allows the cruise control to adapt to this changing environment and thus maintain a more constant speed.

Probably the most sophisticated feedback control system that enters your daily life is the GPS-enabled auto-pilot on commercial airliners, but you'll find thousands of simpler examples if you keep your eyes open for them.

Of particular note are those control systems with "a human in the loop". Your car is a good example. You are making most of the decisions when you drive largely based on what you see, but the car is also supplying you with lots of feedback as a basis for making those decisions. As you turn the steering wheel, the harder you turn the more force you'll feel "pushing back". As you step on the brakes, the harder you push the more the brakes will "push back". Neither of these "push backs" are necessary from an engineering point of view, but they supply you with important information. If you are already making a hard turn, turning even harder could put you into a skid, for example – so the car is designed to give you this feedback.

Stability

Stability is a concept from what is known as "control theory" that I think needs to be mentioned. Forgive me, the example is going to be *really* contrived so that you get the gist of the idea without getting too technical.

Let's go back to the cruise control example. Suppose for some strange reason the feedback on the car's speed didn't get to the controller until ten seconds after the speed actually was measured. That is, the controller is always seeing the speed as it was ten seconds ago. What would happen.?

Well, as you started to climb a hill and slow down, the controller wouldn't know it for ten seconds, and your car might slow quite a bit before the cruise control hit the accelerator. Conversely, then you got to the top of the hill, the controller would keep the accelerator depressed and, combined with gravity pulling you down the hill, that might really have you flying. When the cruise control got that information it would back off on the accelerator, and might even step on the brakes. Now you're at the bottom of the hill, accelerator not depressed and maybe the brakes are on – and they will stay that way for ten seconds into the climb of the next hill, slowing you even more. Personally I'd turn off the cruise control.

The herky-jerky ride you'd get from this sort of situation is one example of what is known as *instability* in a feedback control system. And a delay in getting feedback information is one of the reasons for instability. Hold onto that thought for the next section.

Policy Relevance

So why did I bring this up? It's because feedback control is a concept almost never used in policy formation, and I think it could be to great advantage. Let me give just a few examples.

Should we store high level nuclear waste at Yucca Mountain? Somebody decided that we should do it only if we can demonstrate that it will be safe for 10,000 years. That's open loop control, and basically has been used to block the whole idea – there is really no way to be certain of safety for 10,000 years. So instead we are storing the waste at a large number of far less safe sites around the country. Wouldn't it make more sense to monitor the Yucca Mountain facility and, if anything bad begins to happen (like radioactivity beginning to leech into the ground water), fix it? That would be closed loop, feedback control.

I recently served on a committee to advise the Secretary of Commerce on an aspect of Export Controls. Export Control laws were originally enacted after WW II to keep weapons and critical technologies out of the hands of our adversaries, notably the Soviet Union. They require that before things on a special list of controlled items can be exported, the vendor must get a special license. It made a lot of sense! We wouldn't have wanted some greedy vendor deciding on their own to export our latest fighter airplanes, or nuclear weapons for that matter, to the Soviet Union.

However, the environment has changed. The Soviet Union is no more. The enemy of most concern, terrorists, is not a nation state. The list of controlled items has gotten very long (like regulations, things get added but seldom deleted), and many of the things on it are available from other sources – so the effect is sometimes to either (a) just cause US firms to lose business, or worse (b) to have US firms relocate facilities and jobs overseas so they are not "exporting" the items. What was considered a "supercomputer" in 1980 is a wimp compared to today's PC, yet export control hasn't adapted as rapidly as the technology has changed. The present system is open loop – no recognition of changing circumstances.

If you think about it you'll see that almost all laws and regulations are open loop. The notion of a little more feedback was never considered.

But there is another way to look at it – namely that all laws, regulations and policies are part of a *larger* feedback control system with "persons in the loop", namely the government. Although they would never have said it that way, I suspect that's the model the Founding Fathers had.

Alas, if that's the model, let's think about the instability in our herky-jerky cruise control system. The feedback delay is large in our government. Maybe that was OK in 1787 when our constitution was adopted; life was more slowly paced then. Personally, I'd like to see some more rapid response feedback and control be built into law and regulation today to smooth out the herky-jerky.