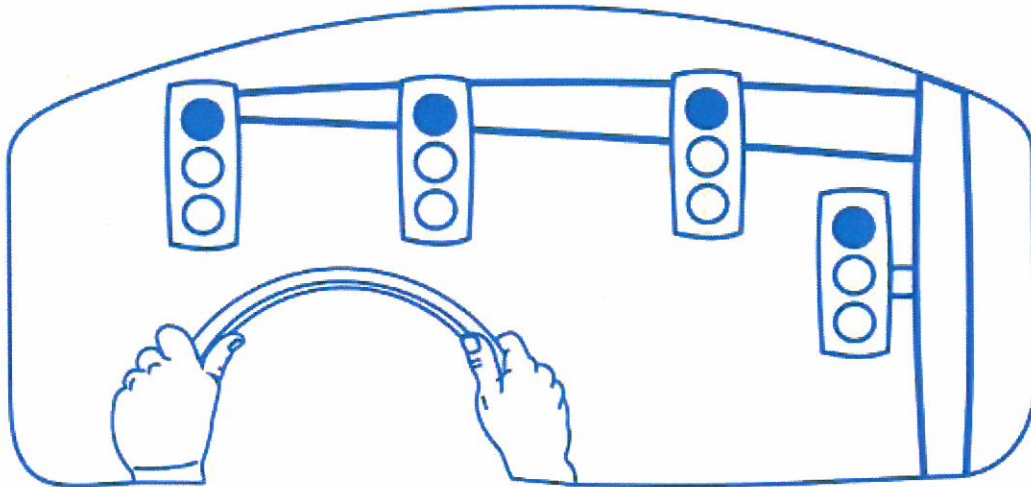


Why is the signal always red?

(or the signal is always greener on the other side)

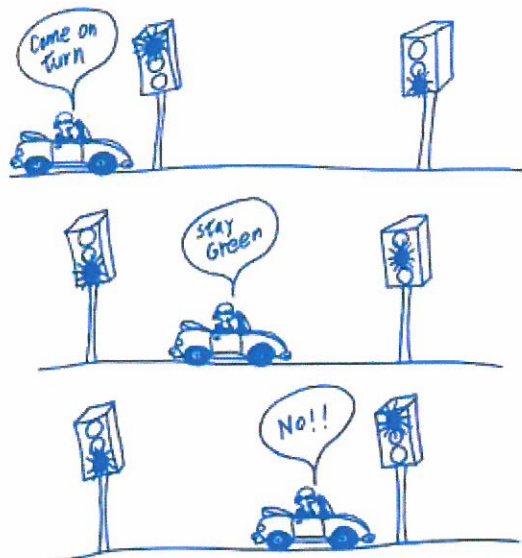


An informative (sometimes informal) brochure on signal timing and coordination

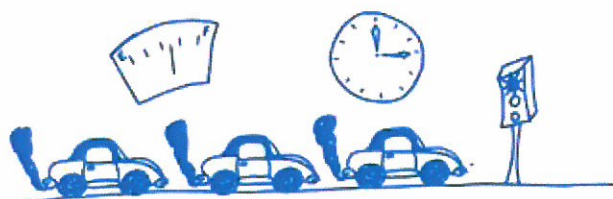


The DENVER REGIONAL COUNCIL OF GOVERNMENTS

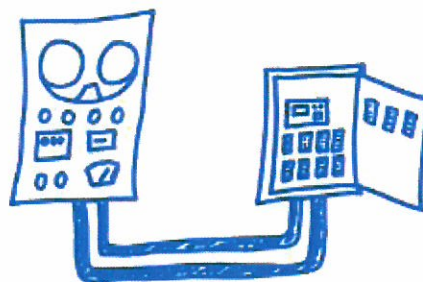
We have all experienced the annoyance of waiting at red lights for so long they seem broken, or the frustration of driving down a street stopping at nearly every light. Sometimes it seems like the lights always turn red just as we get there.



Inefficient traffic signal timing results in congestion and delays which cause wasted fuel, increased air pollution, and wasted time for drivers and their passengers.



Since efficient traffic signal timing is important, why aren't traffic signals timed better? With all the technological improvements in electronics and computers it seems like it shouldn't be difficult to time signals better; however, this is not quite as simple as it may seem.

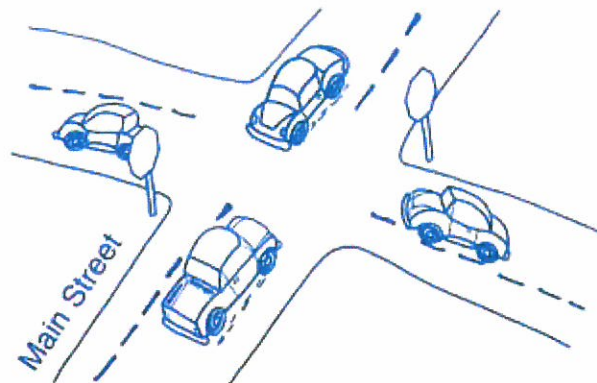


Traffic signal coordination is the timing of traffic signals so that traffic can travel along a street without stopping at every light. Let's look at some of the factors that influence traffic signal timing and coordination.

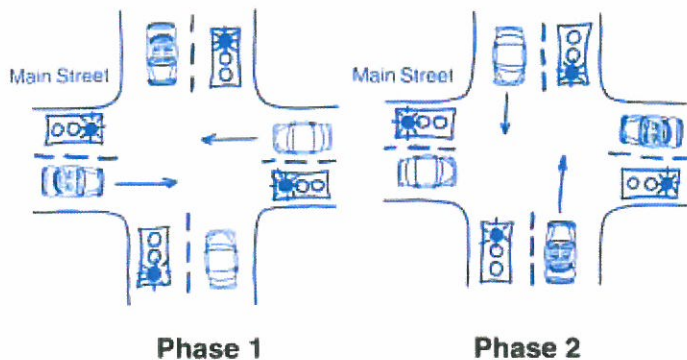
Although many people assume traffic signals are used to prevent accidents, their primary purpose is to assign the right-of-way at intersections.

What does that mean?

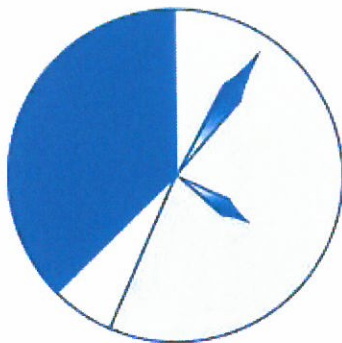
At a simple intersection where only the side street has a stop sign, the main street has the right-of-way. Drivers on the side street must wait for traffic to clear on the main street. (Obvious, but we've all seen drivers who don't seem to understand this concept.)



When the main street traffic is so heavy that the side street traffic can't cross, a traffic signal is used to alternate the right-of-way by alternating which street has the green lights. Each street's green indications are called a **phase**. A simple intersection consists of only two phases; Phase 1 is green for the main street and Phase 2 is green for the cross street.

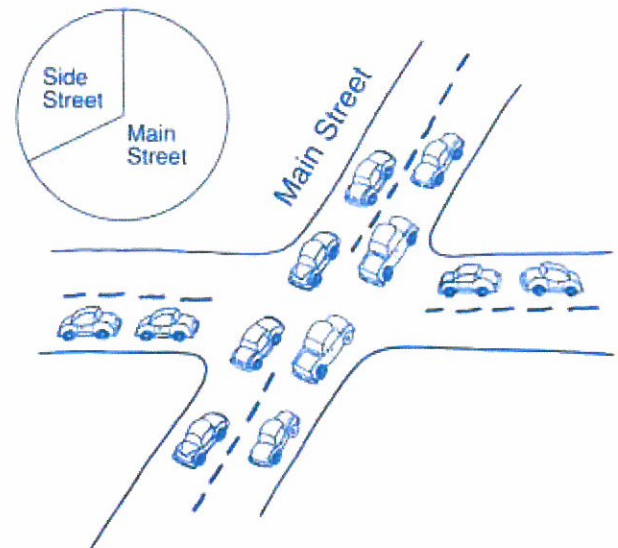


The total time it takes to give both streets the right-of-way is called the **cycle length**. Another way of looking at this is that cycle length is the amount of time it takes for the lights on one street of an intersection to go from green to yellow to red and back to green.



Cycle length

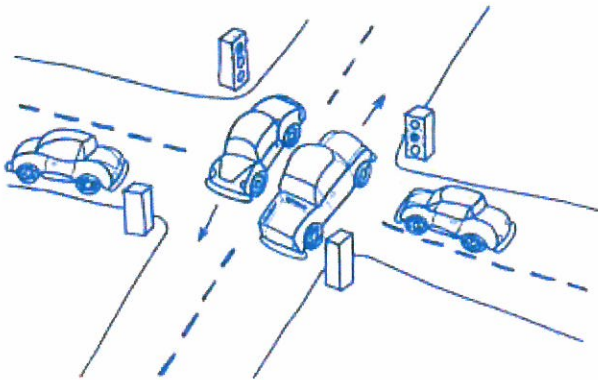
The amount of green that each phase is given is based on the amount of traffic on the streets. For example, if there is twice as much traffic on the main street as there is on the cross street, there should be about twice as much green for the main street. This means the light should be green for the main street about $\frac{2}{3}$ of the time and green for the cross street about $\frac{1}{3}$ of the time.



Unfortunately, it's not quite that easy. Not all of the cycle length is available for green lights.

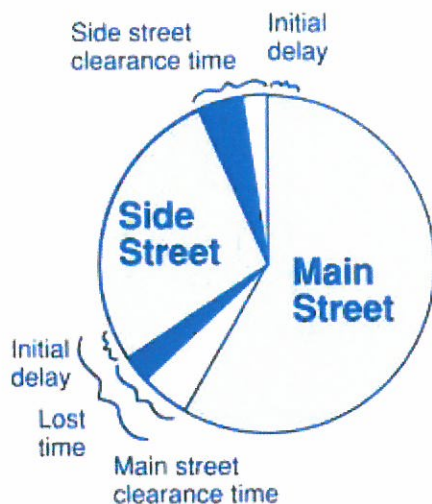
At the end of each green light there is a yellow light to warn drivers of the impending change in right-of-way. However, there are always some drivers who can't (or won't) come to a stop during the yellow light. To accommodate this, there is also a short interval when the signal is red in all directions. This yellow and all-red time is called **clearance time**; without it the signal

would change to green before all the cars from the previous green had cleared the intersection. Clearance time reduces the risk of collisions, but it also reduces the amount of time available for the green.

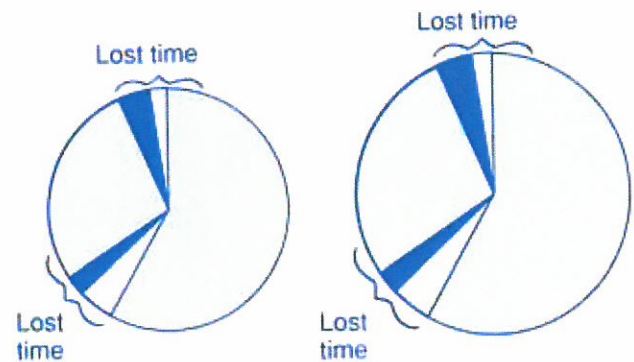


Furthermore, cars seldom start immediately after a signal turns green. It takes time for drivers to recognize that the signal has turned green and to get their cars moving. The combination of this initial delay and the clearance time is called (you guessed it) **lost time**.

Clearance time



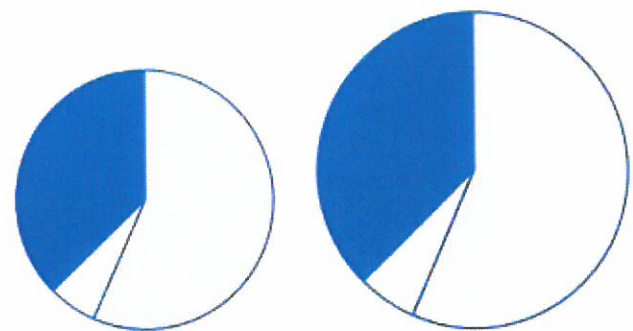
As the cycle length increases, the amount of green time increases; however, the lost time stays the same regardless of the cycle length. This means that the longer the cycle length the greater the percentage of the cycle that the signal is green. This increases the signal **capacity**: the number of cars that can make it through the signal.



Longer cycle - more green

So why don't we use longer cycle lengths?

As the cycle length is increased, the amount of time given to the red lights increases as well. Longer red lights mean longer delays and longer lines of cars.

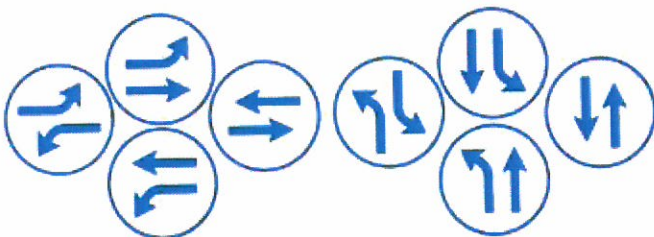


Longer cycle - more red

So we're faced with a trade-off. If the cycle length is increased, capacity increases (*good*), but delays also increase (*bad*). These two factors, delay and capacity, must be balanced.



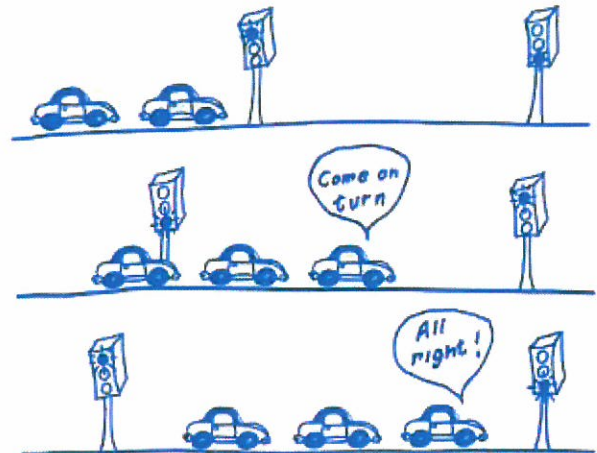
This balancing act becomes even more difficult at intersections with left turn arrows (because these are phases too!). These signals may have eight or more phases and each additional phase uses more of the cycle, leaving less time for right-of-way on the main street. Once all this additional time is allocated, the lights are frequently red much longer than they are green. (You already knew that!!)



Eight traffic signal phases

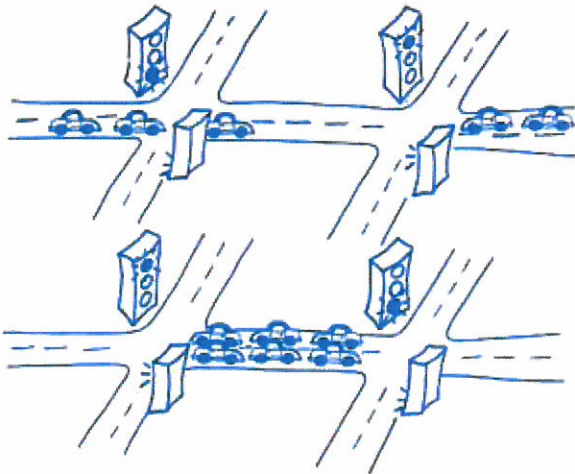
This is how just one signal works. What about several signals in a row?

When cars arrive at a red light, they form lines called **queues**. When the light turns green, the cars leave their queues and travel down the road in tightly spaced groups called **platoons**. If a light is red when the platoons arrive, then several cars have to stop, which is inefficient. To prevent this, each light is set to turn green at a different time. When the starting points of the green lights are adjusted so the platoons can travel through several lights in a row without stopping, then **signal progression** has been achieved.

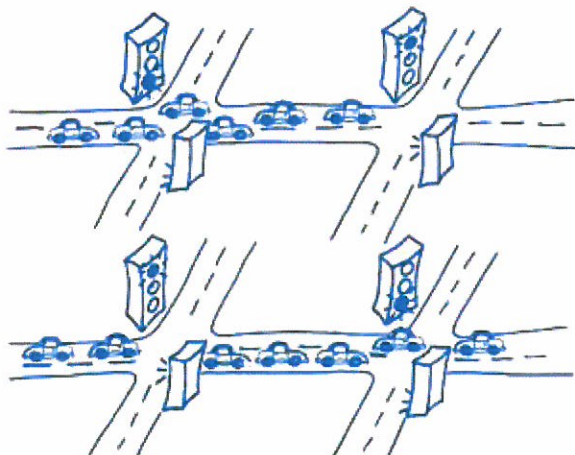


Good progression can always be achieved on a one-way street if the cross streets aren't too busy. But what about two-way streets?

If all the signals on a two-way street were only coordinated in one direction, then travelling the other direction would be like swimming upstream -- travel a block and wait, travel a block and wait. To fix this, the beginning time of the green lights must be further adjusted to allow



progression in both directions. If all the signals are evenly spaced, fairly good progression can still be achieved, but the "quality" of this progression can be very sensitive to the cycle length. Some cycle lengths will provide better progression while others may not allow any progression at all.



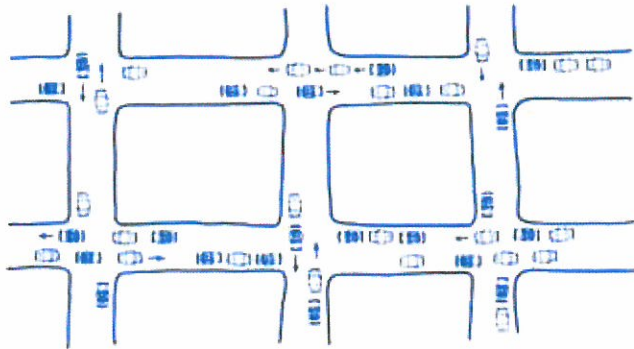
In selecting a cycle length, not only do capacity and delay have to be balanced, but progression must also be considered (This sounds more like a juggling act).



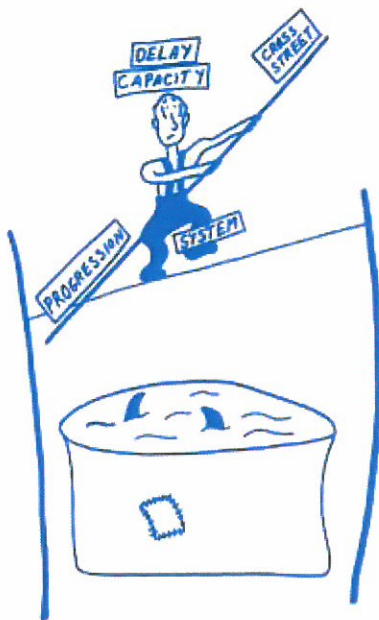
When the signals are irregularly spaced, providing progression can be a very difficult task. On some streets, full two-way progression is only possible for very short stretches.

When the cross streets must also be coordinated, the trade-offs become even more complex. Now delay, capacity, main street progression and cross street progression must all be balanced.

Coordination is most complicated in a grid system of rectangular blocks with signals on each corner, and can only be done with computer programs.



Clearly, coordinating traffic signals can be a very complex technical activity. Trade-offs between vehicle delay, intersection capacity, main street progression, cross street progression and system communication must all be considered. Frequently other problems must also be overcome.



Often there is very good progression for several signals then, as if some barrier were crossed, traffic is stopped at every light. This contradictory performance is frequently the result of crossing community boundaries.

Quite often communities do a good job of coordinating the signals within their own boundaries, but they have no coordination with the signals in adjacent communities. Even when adjacent communities try to coordinate the signals across their boundaries, communication can be a major problem because their traffic signals are often controlled with completely different computer systems. In many cases these systems just can't "talk" to each other. Solving these problems can be expensive and requires taking a larger, more regional view than most communities have the resources to do.



Even when good coordination plans are developed, they must be updated whenever traffic volumes change significantly or new signals are added. In growing areas this may mean completely re-timing signals every three to five years.

Despite the difficulties, the benefits of good traffic signal coordination are so significant that substantial effort is being dedicated to making improvements. The benefits of improved traffic signal coordination include:

- **Reduced auto air pollutant emissions.**
With air pollution a continuing concern, this is an important benefit. Significant reductions in carbon monoxide emissions, as well as other pollutants, can be achieved through improved signal coordination.
- **Reduced delay for drivers.**
Improved signal coordination reduces the number of stops drivers have to make and the delay they experience when stopped. Multiply a small time savings by the thousands of cars on the road and it becomes a significant amount of time.

- **Improved roadway efficiency.**
The weak links in the arterial roadway network are typically the signalized intersections. Reducing the congestion at these bottlenecks can significantly improve operating conditions within a corridor for relatively little money.
- **Decreased fuel consumption.**
Reducing the need to stop and go, stop and go, as well as the idling time while waiting to go, saves fuel.

Because of these significant benefits, the Denver Regional Council of Governments has an active Traffic Operations Program underway. Working with traffic engineers from local governments and the state, this program concentrates on improving traffic signal coordination throughout the region.



Denver Regional Council of Governments
2480 W. 26th Ave., Suite 200B
Denver, CO 80211-5580