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## COMMON DEFICIENCIES OF SIGNALIZED INTERSECTIONS

The following text discusses my top "pet-peeves" with respect to traffic signals. It is an update of a previous article that I wrote for the IMSA Journal back in 2002. This list of common deficiencies is in no particular order:

- 1.) **Non-Use of Right Turn Overlap Phasing.** For the most part, right turn overlap phasing provides "free" capacity at an intersection. In other words, you can move more cars with it than without it and, if implemented properly, there are no drawbacks to using it. If you have an exclusive right turn lane, whether it be on the main street or a side street, then a right turn overlap phase should always be considered if there is a corresponding left turn phase on the counterclockwise-adjacent approach (otherwise there's no parent phase to "overlap" with). As long as you address the "right turns versus u-turns problem" and make sure that your overlap arrow does not cross an active pedestrian movement (which it shouldn't in most cases), then right turn overlap phasing is a win-win situation. If u-turns must be preserved, as is often the case in urban corridors with a strong access management design, then a U-TURN YIELD TO RIGHT TURN sign (R10-16) can be installed and the right turn overlap maintained.
- 2.) **Overuse of Protected-Only Left Turn Phasing.** In the good old days, everybody had to make permissive left turns at almost every intersection; there just weren't very many left turn arrows. But now-a-days nobody seems to be able to make a permissive left turn anymore, especially down here in Florida where we tend to install left turn arrows by force of habit. Many traffic engineers have become much too conservative in their use of protected-only left turn phasing, using it whenever any aspect of the road is a potential problem (a little too wide, a little too fast, a little too many left turns, a little too much opposing traffic, etc.). Truth be known, protected/permissive phasing (and even permissive phasing) can be used over a very wide range of conditions with considerable success. There are conditions during which protected/permissive phasing can become dangerous; such as offset left turn lanes with poor resulting sight distance. However, it is much more often the case that protected/permissive phasing (or straight permissive phasing) is a better choice than protected-only phasing. The vast majority of drivers act like adults and show good judgment. These responsible drivers should not be made to suffer undue delay because we have tailored our designs to meet the needs of the imprudent driver.
- 3.) **Single Lane Freeway Off-Ramps at Signalized Intersections.** Especially in growing suburban areas, roadway designers need to plan ahead by providing more than the typical one lane at off-ramps. This is particularly true for off-ramps that terminate at signalized intersections. At a minimum, the off-ramp should be sized to provide an exclusive right turn lane and an exclusive left turn lane. If the cross street is 4 or more lanes wide (or might be widened to 4 lanes in the future), then a second left turn lane should be added for a total of three approach lanes on the off-ramp. There is usually plenty of right-of-way surrounding freeway ramps, and few utilities, so this additional width can be provided at a very

reasonable cost. There have been many instances where such forward thinking with respect to off-ramp design would have prevented future capacity problems at the interchange signals.

- 4.) **Use of Exclusive Left Turn Lanes Instead of Exclusive Right Turn Lanes on Minor Side Street Approaches.** When a side street has two approach lanes, some engineers (almost by wrote), automatically designate one lane as a shared thru/right lane and the other lane as an exclusive left turn lane. This is fine if there is a high volume of left turns on the approach or if the number of right turns is low. However, if there is a significant volume of right turns or the left turn volume is relatively low, a shared thru/left and an exclusive right turn lane arrangement is often preferable. Having an exclusive right turn lane permits unobstructed right-turn-on-red whereas, with a shared thru/right lane, just one thru vehicle can bottle-up a long queue of vehicles desiring to turn right on red.

Under the appropriate circumstances, the use of a shared thru/left and exclusive right turn lane arrangement on a two lane side street approach can both increase the capacity of the approach and reduce vehicular delay. Having an exclusive right turn lane might also allow the installation of a side street right turn overlap arrow, further increasing the capacity of the approach.

- 5.) **Non-Use of Low Volume Flashing Operation.** At most signalized intersections, traffic volumes at night (and sometimes on weekends) become low enough to permit the use of flashing operation. If the geometric characteristics of the intersection are typical (not too wide, not too complicated, no sight distance restrictions, etc.) then flashing the signal at night (yellow on the main street and red on the side street) results in a general decrease in delay and is usually well-received by area citizens.

If the intersection is controlled by a fixed-time signal then delay is greatly reduced for both main street and side street motorists by instituting low-volume flashing operation. Intersections controlled by fixed-time signals receive the greatest benefit from flashing operation. However, contrary to what some might say, the operational benefits of low-volume flashing operation are also significant for both semi-actuated and fully-actuated traffic signals. Even with full actuation, vehicles still experience a certain level of unnecessary delay caused by the timing of initial intervals and change intervals (yellow and all-red) for conflicting movements. And if a loop or pedestrian button goes bad causing a phase to "stick-on", then this delay can go from significant to substantial.

I am fully aware of certain past studies that have shown that low volume flashing may increase accidents. There is no doubt in my mind that this is true - if you pick the wrong intersections to flash! The simple solution is to be careful, picking only appropriate intersections.

- 6.) **Squirrely video detection.** Purdue University has done quite a bit of work on analyzing the effectiveness of video detection for traffic signals; and the results are not very encouraging. Far from being the "quality choice" of detection systems, video detection falls prey to a host of operational problems involving such items as occlusion, shadows, headlight glare, wet pavement reflection, reduced image size with distance, non-vehicle actuation, etc. The end result is that, under a variety of somewhat unpredictable conditions, the video detection system sometimes "sees" vehicles that are not there, doesn't "see" vehicles that are there, recognizes vehicles before they enter the detection zone, or misconstrues the real time during which the vehicle occupies the detection zone. Video detection is not all bad, but it's not all good either.

- 7.) **Non-use of delay detection.** Delay detection can be used to reduce the amount of wasted green time when applied to side street right turn lanes, main street left turn lanes controlled by protected/permissive phasing, and minor movement lanes subject to cut-across. Ten seconds of delay on a side street right turn lane will provide the opportunity for a motorist to turn right on red. Five seconds of delay in a main street left turn lane controlled by protected/permissive phasing will, under light traffic conditions when the signal is resting in main street green, allow a motorist to turn left from this lane without bringing up the left turn arrow. Two seconds of delay on a lane subject to cut-across (caused by a motorist from the counterclockwise-adjacent main street approach turning left and encroaching into the side street lane) can keep that phase from being needlessly activated.
- 8.) **Failure to use battery back-up at major intersections.** With the widespread use of LED signal heads, the viability of cost-effective battery back-up systems has arrived. During a power outage, the accident potential at major intersections increases substantially and the justification for uninterrupted signal operation becomes pretty clear. In the future, solar or wind powered batteries may be able to operate the signal during “normal” periods as well, thus saving energy and reducing operating costs. (We might even be able to sell excess energy back to the power company!) And running the signal off of the battery system even part of the time helps ensure that the back-up power system is working when an emergency does occur. By the way, using red-red conflict flash at these major intersections instead of red-yellow flash is another item that should be seriously considered.
- 9.) **Premature Use of Dual left Turn Lanes.** If one left turn lane is good, then shouldn't two left turn lanes be better? Not necessarily. Two left turn lanes require the use of protected-only left turn phasing whereas a single left turn lane can be controlled by less restrictive protected/permissive phasing (or simple permissive phasing). Unless peak hour traffic volumes at the intersection are such that a dual left turn lane is really needed (and this is best determined through a formal intersection capacity analysis), or unless protected-only phasing is needed for some other reason (such as a sight restriction or a bad accident history), a single left turn lane is preferable. If it is expected that traffic volumes will increase to the point that a dual left turn lane will be needed in the future, then room can be set aside in the median for a future second left turn lane or the second lane can be installed now but "striped-out" for future use. If the second lane is striped-out, it is usually best to stripe-out the outside left turn lane rather than the median left turn lane in order to reduce the potential for sight obstruction associated with offset left turn lanes.
- 10.) **Fancy side street medians, but not enough approach lanes.** It is not uncommon in Florida to have a signalized intersection where the main access road for a major housing development or a major shopping facility intersects an arterial. Often this access road has a wide, nicely landscaped median with a fancy sign indicating the name of the development. There's no problem with this, unless the fancy median is being provided instead of a full complement of approach lanes (at least two and preferably three). Another related problem is the provision of two incoming lanes to the development but not enough outgoing (approach) lanes. Two incoming lanes are often unnecessary and should never be provided at the expense of approach lanes.
- 11.) **Poor Signal Coordination.** Having spent many years developing and implementing coordinated signal

timings on a wide variety of equipment, and over a wide variety of corridors, I fully appreciate the difficulty involved in the task. Consequently, I hate to criticize our profession in this technically difficult area, but it must be done. We have not done a very good job of implementing and maintaining good coordinated timing plans. Traffic signal controller quirks and real-world road network anomalies (frontage roads, compressed diamond interchanges, 5-leg intersections, staggered intersections, closely-spaced intersections, cross-coordination issues, exclusive pedestrian crossings, etc., etc., etc.) make the development and implementation of workable coordination plans as much of an art as it is a science.

The simple truth is that some traffic engineers and some traffic technicians are good at it, and some are not. It requires a type of inductive logic and willingness to "tinker" that not all engineers possess. Even if you are quite good at running one of the many increasingly-sophisticated coordinated signal timing computer programs that are available, if you cannot convert the results into settings that the different controllers understand, or if you cannot adjust your results to accommodate real-world anomalies, or if you cannot decide when to turn-on and turn-off the various plans so that the right cycle length is used at the right time, or if you cannot develop settings that keep left turn queues from spilling-over into thru lanes, then your timing plans will start to smell under the heat of implementation.

The bottom line is that there needs to be in-the-field, hands-on training of engineers in the proper implementation of coordinated signal timing plans. And we also need to spend time training traffic engineers and signal technicians on how to both check the plans and maintain the plans once they are implemented.

- 12.) **Evaluation of signal coordination that ignores minor movements.** The standard approach for evaluating a traffic signal coordination project is to perform before and after travel time runs along the main street. The major drawback of this approach is that improved travel times along the main street can often be obtained at the expense of side street motorists and/or main street left turn motorists. It would be hard to call a traffic signal retiming project a success if it reduced travel times along the main street by 10% but increased phase failures and delay on the side street by 50%. Unfortunately, we don't have a widely accepted technique for including minor movement delay into the evaluation process.
- 13.) **Difficult to Read Street Name Signs.** Florida has been a leading state with respect to improved street name signing, and a number of good ideas continue to be aggressively pursued:
  - A.) The use of large letters (at least 6-inches in height) for street name signs,
  - B.) The use of advanced street name signs at signalized intersections (located a few hundred feet upstream of the signal on all approaches), and
  - C.) The use of photocell-controlled, LED illuminated street name signs at signalized intersections, signs which hang from the signal mast arms or from brackets attached to the signal support poles.
  - D.) The use of new Clearview letter fonts that are recognizable by motorists at greater approach distances.

All of these are excellent ideas for improving the driving experience of the motorist. Traffic volumes are increasing throughout the nation and, because of both baby boomer demographics and improved health care, our driving population continues to get older and older. These two trends increase the need for clear roadway signing. Motorists who slow to read dimly lit or small street name signs, or who shoot over to make a turn at the last minute because they recognized a street name too late, are dangerous. Signing improvements reduce this potential while making life easier for all motorists.

- 14.) **Confusing Pedestrian Indications.** With the growing use of countdown pedestrian signals we are finally making progress towards removing the confusion associated with pedestrian indications. Being able to see the time remaining to cross the intersection not only gives the pedestrian a certain level of comfort, but it also reinforces to the pedestrian the true meaning of the flashing don't walk interval (that it is a clearance interval which allows the pedestrian to complete the crossing). We need to continue this progress by replacing all non countdown pedestrian signals as soon as possible.

Another item that would help restore the public's confidence in pedestrian signals is a pedestrian push button which "lights up" when it has been pushed so as to indicate when a call has been placed for the pedestrian interval. When the WALK indication is displayed, the light goes out. This button operates much the same way that an elevator call button does (which lights up when a person pushes it and goes out when the elevator arrives). It has a familiar operation that the average person can understand. Having a lighted call indicator will inform the pedestrian that their request has been recognized (with standard pedestrian buttons, no such acknowledgement is provided), thus reducing both the temptation to cross the street before the WALK indication is provided, and reducing the incentive for pedestrians to continue to "mash" the pedestrian button. I have seen a few of these push buttons in use at the University of Florida's main campus in Gainesville and they work well.

- 15.) **Ugly Signal Supports.** When intersections are large, or when swale drainage systems require that signal support poles be set-back a long distance from the edge of pavement to meet clear zone requirements, the cost-effectiveness of a strain pole/span wire design becomes obvious. However, with smaller intersections, or in areas where curb-and-gutter drainage allows the poles to be placed near the edge of the road, decorative paint-over-galvanized mast arms are much more attractive than ugly wooden (or concrete) poles and span wires. This is especially important in aesthetically sensitive areas such as downtowns or entertainment areas. When possible, we should make things look nice. (A few years ago in Florida we had some trouble with paint over galvanized finished due to poor workmanship, resulting in peeling mast arm finishes. In our plans, we are now requiring a 5-year warranty bond on all mast arm finishes.)
- 16.) **Minimum signal head separation for thru movements.** The MUTCD requires 8 feet of head separation. Many jurisdictions center the signal heads on the lane which, for multi-lane approaches, typically results in a head separation of 12 feet. However, even with 12 feet of separation, signal head visibility can be compromised by trucks in the traffic stream. Increasing the horizontal separation of signal heads whenever possible is a prudent strategy that maximizes visibility.

These are my top traffic signal annoyances; it is by no means an exhaustive list.