Gridded Streets Report FAC/FCA-039

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Introduction: Three arguments are frequently presented to encourage the use of a grid of streets in development and re-development: (1) automobile drivers have alternative routes that permit easier flow of traffic; (2) retail stores are more accessible via on-street parking; and (3) delivery trucks have easier access to all units. The last two arguments can be offset by the arrangement of the streets and buildings. The purpose of this report is to present an analysis of traffic flow pertaining to the first argument.

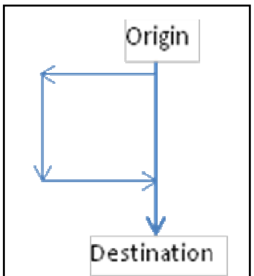
Summary: The grid and artery routes will have equal time if the amount of traffic on the artery sufficiently exceeds the capacity of the artery. Our analysis uses the incoming traffic either flowing down an artery through an intersection with a grid street. We considered two cases: either the artery traffic encounters a green light or encounters a red light so that it is delayed 30 seconds ("Delay on artery due to red light" in Exhibit 1). The grid street provides an alternative route. In both cases, the alternative route through the grid is initiated without delay by a right turn on red. If the destination is on the artery, using the grid as a bypass is a slower route if the artery is less than 121% of its capacity – 138% if the artery flow does not encounter the initial red light (Exhibit 1). The corresponding backups are 1.6 miles and 2.8 miles, respectively. If the destination is inside the grid, driving through the grid is slower if the artery flow is not stopped at the red light and the demand is less than 104% of its capacity, but the artery is slower if the artery flow is stopped by the red light. At 104% capacity, the backup is 0.3 miles. For comparison, the backup during the 30 second red light is 0.06 miles.

Delay on artery due to red light, sec	0	30
Grid as bypass	138%	121%
Grid point as destination	104%	0%

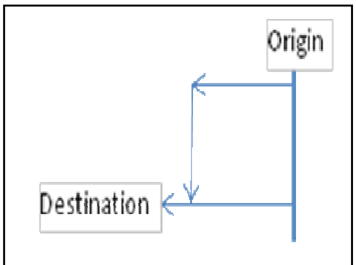
Exhibit 1: Traffic Demand as a Percentage of Artery Capacity at Which Travel Times Are Equal

We have used one block of a grid, 0.1 miles square. If the path lengths are longer, the grid will be less advantageous because the speed limit is lower on the grid streets. For example, even with the 30 second red-light delay and the destination inside the grid, the artery is faster if the destination is 0.5 miles from the origin in the direction of the artery flow. We have assumed that the artery speed limit was 35 mph and the grid speed limit is 25 mph.

Discussion: To analyze the performance of a grid of streets, we examined two cases: (1) the destination is along the artery so the grid is used as a bypass when the artery traffic is too heavy and (2) the destination is inside the grid so that artery drivers must eventually enter the grid. The two cases are illustrated in the following diagrams. The first shows the grid being used as a bypass; the second, as an alternative route. The heavier line is the artery; the lighter line, the grid.



Grid as bypass



Grid point as destination

We chose the following parameters, all of which favor the grid as an alternative.

1. Artery speed limit: 35 mph
2. Artery has two lanes in each direction
3. Grid speed limit: 25 mph
4. Grid street has one lane in each direction
5. Grid block 0.1 mile square
6. Traffic lights at the intersections of a grid street with the artery
7. Stop signs for the horizontal grid streets when encountering a vertical grid street (vertical grid streets are parallel to the artery).
8. No stop signs along the vertical grid streets
9. Traffic light at the intersection near the origin red for 30 seconds for artery flow (or 0 seconds).
10. Peak vehicles per hour emanating from the origin and terminating at the destination persists for one hour.

For the intersection parameters we used parameters that we measured in the field:

- 5 seconds for an immediate turn
- 10 seconds for a stop sign or a right-turn on red after stop

We used the Akçelik speed-flow model[1] for the artery and assumed that the grid flow was so far below capacity that the running time was the free-flow time (i.e., distance divided by speed limit). In our analysis, we used the length of the peak-demand time as one hour and a Ja of 0.194. The Akçelik equation is:

t = t0 + 0.25*T*[(x-1) + sqrt{(x-1)^2 + 8*Ja*x/(Q*T)}]

where:

t	average travel time per unit distance (hours/mile)
t0	free-flow travel time per unit distance (hours/mile), We used t0=1/speed limit because delays were separately modeled.
T	flow period, i.e., the time interval in hours, during which an average arrival (demand) persists
Q	Road capacity, vehicles per hour
x	the degree of saturation i.e., v/Q (v=actual vehicles per hour)
Ja	the delay parameter, with the units of vehicles

This equation is not dimensionally consistent, because T is in hrs, whereas t and t0 are in hrs/mile. In all of the examples we found on the Internet and in the Highway Capacity Manual, T was one hour; therefore, we used T equal to one hour in our analysis. Delays due to signals are usually included in t0; however, we have treated them separately, as described above.

The results of our analysis are presented in the Summary. The conclusion is that, except in unusual circumstances of small block sizes and a short distance from origin to destination, a grid of streets cannot be justified on the basis of traffic flow. The disadvantages of a grid of streets, as compared to a grid of walkways (between buildings), are the greater space between buildings and the greater hazard to the pedestrians. Greater distances between buildings result in less efficient land use and longer walking distances.

[1] Akcelik_Travel_Function_1991.pdf and Highway Capacity Manual, Eqn 15.3.