The Parallel Flow Intersection

A High Capacity Signalized Traffic Junction

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A simple idea: *left turns bypass the main intersection by first turning onto a cross street frontage road.*

The result: *a relatively low cost improvement that can greatly reduce congestion and improve safety.*

Fig. 1 – Parallel flow intersection

The patented parallel flow intersection (PFI) is a new traffic innovation able to **reduce vehicle delay by as much as 90%** over a comparable traditional signalized intersection because the PFI has only two or three phases per signal cycle.

This increased efficiency is accomplished by arranging for left turns to occur just prior to the main intersection using a cross street frontage road (Fig. 1 above). Left turn movements are then able to proceed in the same signal phase as the cross street through movement.

And unlike many unconventional intersection designs, the PFI provides for intuitive direct left turns nearly from the same stop bar location as a traditional signal.

Advantages over traditional intersections:

Efficient

- Can reduce vehicle delay by as much as 90%
- 2- or 3-phases per signal cycle for shorter cycle lengths and less lost time

Greener

- Less fuel usage
- Improves air quality and reduces pollution
- Channelizing islands create landscaping opportunities

Safer

- Fewer conflict points
- Removes unsafe 'permitted' left turns
- Channelizing islands create pedestrian refuge

Lower Cost

- Much less cost and impacts than interchange construction
- Fast conversion of existing traditional intersection and safer work zone

Other benefits:

- Flexible geometry to fit variety of physical site requirements
- Intuitive to drive
- Can be constructed in various intersection or interchange variants

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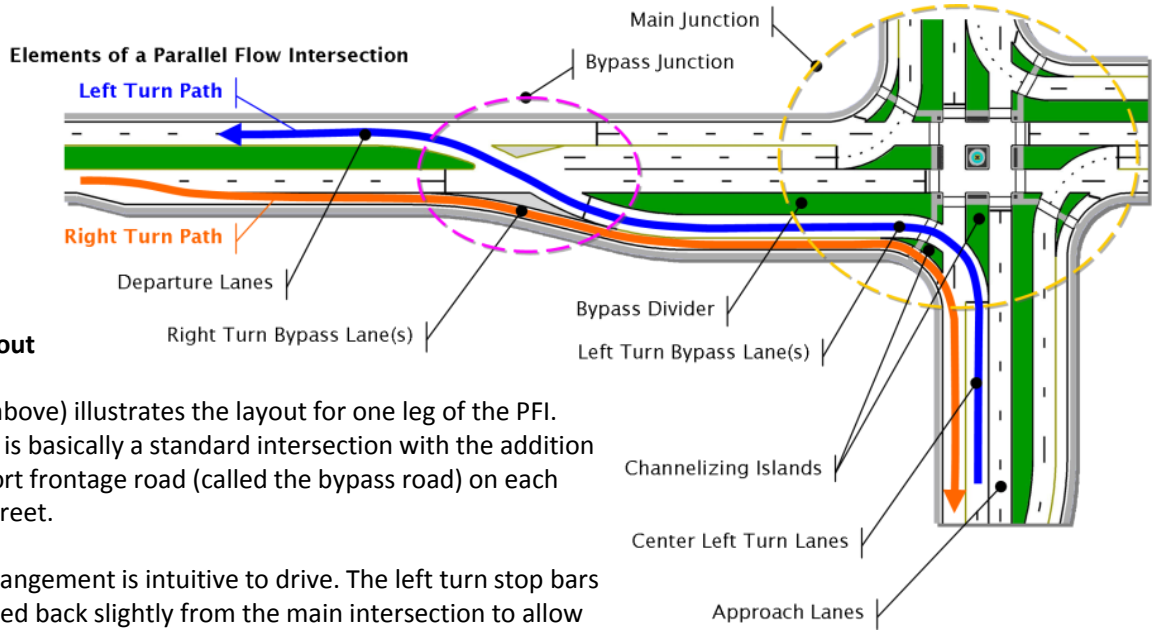


Fig. 2 - Layout

PFI Layout

Fig. 2 (above) illustrates the layout for one leg of the PFI. The PFI is basically a standard intersection with the addition of a short frontage road (called the bypass road) on each cross street.

This arrangement is intuitive to drive. The left turn stop bars are pulled back slightly from the main intersection to allow left turning vehicles to turn onto the bypass lanes that are located parallel and adjacent to the cross street.

A Simple Conversion

Converting an existing intersection to a PFI can be simple, fast and provides for a safer work zone.

As Fig. 3 (below) illustrates, most new pavement construction is on the outsides with only minor construction for channelizing islands within the existing roadway.

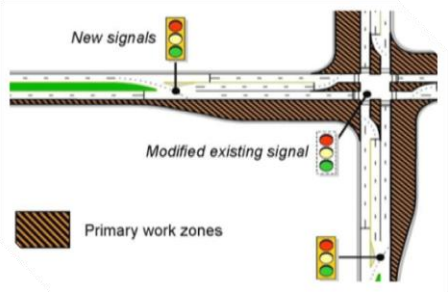


Fig. 3 - Conversion

PFI Signal Operation

The operation of a typical 2-phase PFI is schematically represented by Fig. 4 (right).

The signal coordination is simplified with only two phases per cycle and can be setup with a fixed timing plan that remains constant throughout the day.

The main junction of a PFI is always signalized but the bypass junction can be signalized, grade-separated or a modern roundabout.

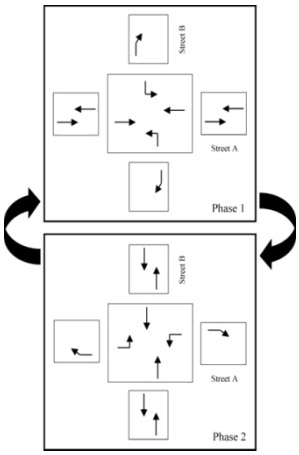


Fig. 4 - Phasing

Less Vehicle Delay

Average vehicle delay accumulates when vehicles are moving at a crawl or stopped at the intersection during a peak hour period.

Fig 5 (below) shows results of a comparative analysis by the author of a hypothetical four leg intersection with two through lanes on each approach, a total volume of 6,375 vehicles per hour, and 30% left turns. The PFI is expected to reduce delay by nearly 90% over a traditional intersection and by about 70% of a 3-lane modern roundabout. The PFI and the other 2-phase design, the continuous flow intersection (CFI), would be nearly equal.

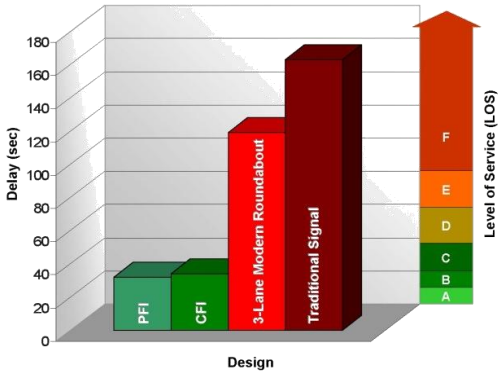


Fig. 5 - Average vehicle delay

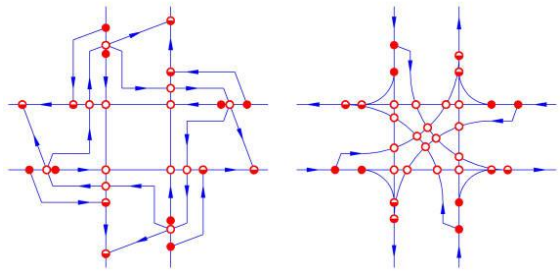
Level of service (LOS) is a performance measure used to grade intersections on a scale from A to F. The LOS is based on average vehicle delay with A being the best and F the worst. At LOS A, traffic is free flow and at LOS F, traffic is stop-and-go. The minimal desirable LOS for most urban intersections is LOS D. Fig. 5 shows the relative LOS results of the three intersection types analyzed.

For this comparison, the PFI showed a significant reduction of delay achieving LOS C while the modern roundabout and traditional intersections were both at LOS F.

Fewer Vehicle Conflicts

Fig. 6 (below) shows the number of conflict points of a 2-phase PFI and traditional intersection. A conventional intersection has four more conflict points than the PFI and of the "crossing" type which is typically the most severe crash at an intersection.

With less delay and vehicle queuing in addition to fewer conflict points, the PFI is expected to be an overall safer intersection than traditional signalized intersections.



Parallel Flow Intersection

Traditional Intersection

Type of Conflict	Parallel Flow Intersection	Traditional Signalized Intersection
Diverging	8	8
Merging	8	8
Crossing	**12**	**16**
Total	28	32

Route

Fig. 6 – Vehicle conflicts

Pedestrian and Bicyclist Safety

The presence of channelizing islands at the PFI offers pedestrians refuge for multi-stage crossings. Bicycle lanes can be added to accommodate bike movements through the intersection. And with no permitted vehicle left turns, the PFI can make pedestrian and bike movements even safer.

PFI and CFI Compared

The continuous flow intersection (CFI), or displaced left turn, is a patented (now expired) 2-phase signalized junction and has been constructed in Mexico and United States. Though the CFI removes left turns from the main junction with a bypass ramp similar to the PFI, the geometry and operation of the CFI are quite different.

As shown in Fig. 7 (below), the CFI places the bypass ramp on the approach road and displaces the median left turn lanes from the main junction. The PFI uses its bypass road as a frontage road and stores vehicles requiring a two stage left turn. The CFI is designed and signals timed to have left turn vehicles clear the bypass ramp without stopping in a single stage movement.

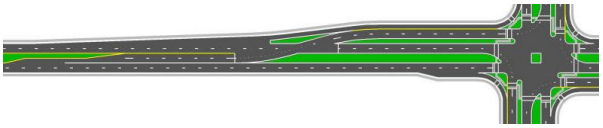


Fig. 7 – CFI layout (one leg)

In general, the CFI requires nearly twice the approach length of the PFI due to the displaced left turn as show in Fig. 8 (below). The PFI places the bypass road on the cross street. By doing so, the PFI overlaps the bypass and cross street median turn lanes.

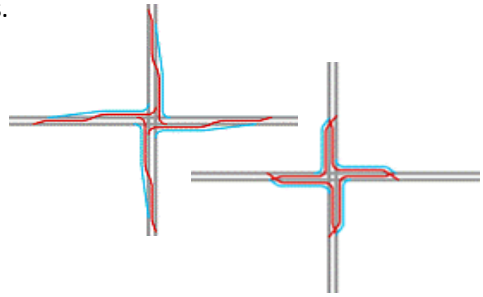


Fig. 8 – Size comparison (2-phase)
CFI (left) and PFI (right)

The decision to construct a PFI or CFI will generally be site specific. Physical features such as nearby intersections, existing driveways, and adjacent buildings will likely govern.

Capacity of the PFI is similar to the CFI with the CFI having slightly more when there is greater left turn volume and PFI when there is more right turn volume.

Drivability is higher for PFI since the left turn is direct and occurs at the main junction. The CFI will generally require overhead approach signs and the PFI needs only standard signage.

Operation of the PFI is simpler than the CFI (as currently implemented) since the PFI stores vehicles on the bypass road and the CFI clears in a single phase. (The author is unaware of any CFI's in operation storing left turns on the bypass.) For vehicles to clear in a single phase, the CFI geometry and signal operation is more complex than the PFI.

Access impacts of the CFI are generally greater given its approach length. A CFI can require an additional access road to be built. Because the PFI requires much less approach length and the bypass acts as a frontage road, the PFI will typically result in fewer access impacts.

Construction time of the CFI will often be greater if no existing median is available for the displaced median left turn lanes. The existing through lanes might have to be shifted to make room. Most of the new pavement for the PFI is placed on the outside of the existing roadway resulting in faster and safer construction.

Cost of the PFI can be considerably less than the CFI given the potential for fewer access impacts, less pavement, and faster construction time.

PFDI and DDI Compared

The diverging diamond interchange (DDI), or double crossover diamond, is a new 2-phase service interchange design. The DDI is appealing because it can increase capacity of an existing diamond interchange at relatively low cost. The DDI is unusual in that it removes left turn conflicts by crossing arterial traffic to the opposite side as shown in Fig. 9 (below).

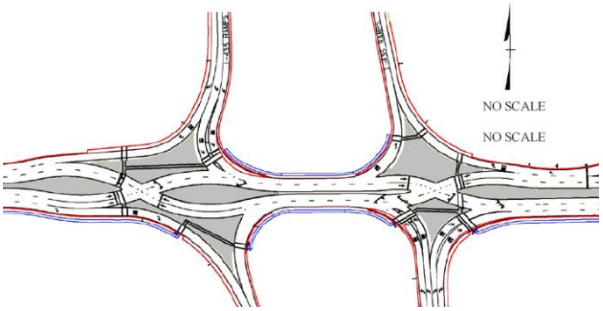


Fig. 9 – DDI layout (from FHWA AIIR publication)

The DDI has been successfully constructed at a few locations in the United States with more planned. But while the DDI does increase capacity of a traditional diamond, under certain conditions the PFDI can be a more desirable solution. The parallel flow diamond interchange (PFDI) can be constructed either spread or compressed. The general layout for each is shown in Fig. 10 (below).

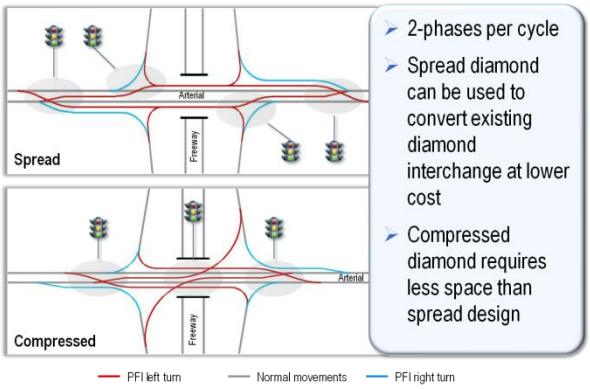


Fig. 10 – PFDI layout variants

The PFDI offers the advantage of not crossing arterial through traffic to the opposing side which can be a potential safety concern and cause of delay.

For very high and balanced directional vehicle volumes on the arterial, the PFDI can provide higher capacity than the DDI.

For freeway-over-arterial sites, the deciding cost factor will typically be whether there is enough space under the existing bridge end spans for the bypass ramp lanes to be added. If not, the PFDI alternative would require replacement of the existing bridges.

Generally, the PFDI will cost more to construct when converting an existing arterial-over-freeway site than the DDI. This is true if bypass ramps need new bridges but is not necessarily so for new construction.

Fig. 11 – Modification of existing bridge end span slopes for PFDI conversion

Traffic analysis performed by the author using microsimulation software indicates that the PFDI has potentially much higher capacity than the DDI. This is mostly due to the PFDI not creating conflicts between arterial through movements.

Last, the PFDI better meets driver expectation by not crossing traffic into opposing travel directions as the DDI does. The DDI permits the crossover maneuver to occur at high speed increasing the potential for head-on collisions.

Learn More

If you are interested in learning more about the parallel flow intersection, please visit our website at www.gfparsons.com. Here you will find contact information, obtain more details on the PFI, and can view traffic micro-simulations of the PFI in operation.

United States Patent

The parallel flow intersection (PFI or paraflow) design is protected by U.S. Patent No. 7,135,989 and held by Greg Parsons. We encourage inquiries before any plan to implement and use the PFI and derivative designs are advanced.

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Some of the Many Parallel Flow Variants

4-Leg / 2-Phase Intersection

4-Leg / 3-Phase Intersection

2-Phase Diamond (Compressed)

2-Phase Par-Clo (Compressed)